USE OF TOOLS

BASIC
NAVY TRAINING COURSES

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USE OF TOOLS

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PREFACE

This book is prepared as a basic reference for those enlisted men of the Navy whose duties require them to use tools to keep Navy gear and equipment in shipshape condition.

Familiarity with tools and knowing how to use them is of primary importance to technicians of all rates, for even the most simple routine jobs require the use of tools. Tools are indispensable in the maintenance and repair of Navy equipment, and a technician—whether he is concerned with radio, electricity, ordnance, propulsion machinery, metal work, or woodworking—cannot get along without calling upon his tools for assistance.

In this book, tools are arranged in groups according to the kind of work they are designed to perform. The book begins with advice on the handling of such general purpose tools as hammers, screwdrivers, pliers, punches, and wrenches. It explains the use of the tools used for cutting and shaping metal—chisels, hacksaws, files, snips, drills and reamers. Chapters are devoted to threading tools, pipe and tubing tools, woodworking tools, measuring tools, gages and indicators, soldering and welding tools, special tools, metal fastening devices, and abrasives.

As one of several Basic Navy Training Courses, this book was prepared in the Training Courses Unit, Standards and Curriculum Division, Training, Bureau of Naval Personnel.

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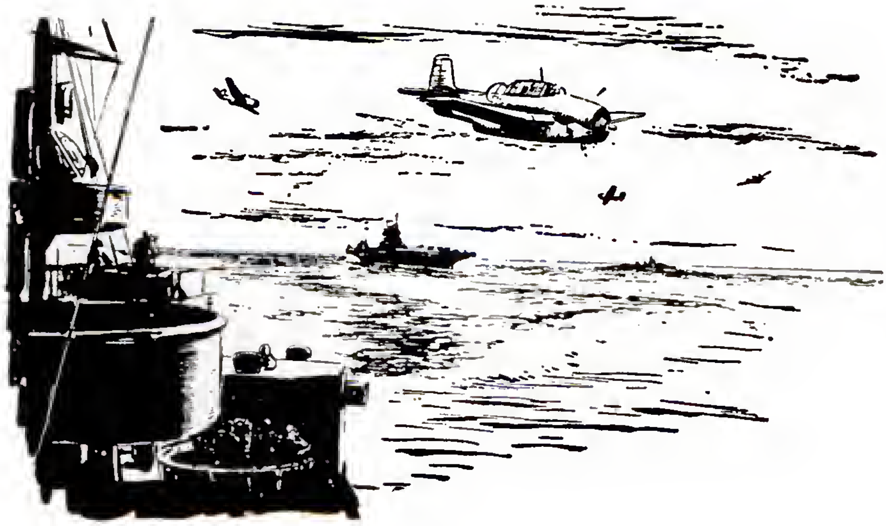


CHAPTER I

KEEPING OUR NAVY SHIPSHAPE

GOOD FRIENDS

Tools are your good friends. Why? Because they make it possible for you to do hundreds of jobs that you couldn't do with your own hands. They are EXTRA hands—and EYES—which give you countless new skills. If you TREAT the tools you use as FRIENDS, they'll always be ready to help you when you need them most.

Like friends, tools become more valuable to you the better you're acquainted with them. You'll find that they require careful handling, and that they don't go for any ROUGH STUFF. But, if you follow a few simple rules concerning tools, they'll last longer and stay in good condition indefinitely.

Your daily work in the Navy will undoubtedly involve the frequent use of tools, whether you're at a shore base or aboard a ship. Chances are that you have become familiar with certain general-purpose tools in civilian life, but it's a good bet that you'll get acquainted with a number of new ones in Navy shops.

So, if you DON'T know all the answers about tools when you join your outfit, make it your job to LEARN. MAKE USE OF YOUR TRAINING COURSES. Start asking questions. Get someone with experience to help you find the answers. Then work WITH tools in the shop until you know ALL about them.

BASIC RULES ON BASIC TOOLS

A lot of fellows try to kid themselves that tools can stand all kinds of punishment just because they're made of steel or other durable-sounding materials. Any fellow that feels that way is in for a lot of GRIEF. Actually, tools have to be BABIED or they'll go to pieces in no time at all. And when you're in a combat zone, there is only a LIMITED SUPPLY of tools. You won't get any more than are issued to you originally. If you BREAK one of them, it may be a long, long time before you can get a replacement.

Put those tools not in actual use in a safe place while you are working. A tool may break if it falls on the deck or the ground. Aboard ship, make certain that tools are SECURED so that they won't tumble off benches or fall overboard. And be SURE to PUT TOOLS AWAY WHEN YOU ARE THROUGH WITH THEM. If you leave them lying around you might easily trip over them and injure yourself.

You'll probably work with tools in a SHOP. It may be a small shop, but there will at least be a workbench, a workbox, and special kits of tools for special jobs. To save time and to avoid needless waste, assign each tool to a place in the workbox or kit, and see that each tool is kept in its place. BEFORE putting a tool away, check it for dirt or rust. Dirt and rust are vicious enemies of all tools.

A workbench that looks like a junk heap is a menace. It's impossible to do GOOD work when tools are mislaid.

A particularly bad practice is leaving sharp tools protruding from workbenches. They will tear, rip, or puncture any moving object that comes in contact with them, INCLUDING YOU! For the same reason, don't carry sharp tools in your back pocket. When you're assigned to a workbench, keep it clean and orderly, and not like the one shown in figure 1. This horrible example fairly screams for a field day.

Figure 1.—Invitation to a field day.

USE THE RIGHT TOOL

Select the proper tool for the job at hand. Some tools can be used for several purposes, but they all have limitations. Plain common sense will tell you that you shouldn't use a tool on a job for which it was not designed.

The screwdriver, for instance, is a tool designed to loosen and tighten screws. Don't try to use it as a cold chisel—you'll only ruin the handle and chip the point. Don't use your screwdriver as a pry bar—it may bend or snap in two. You can't do a good job if you tackle it the wrong way.

The way in which you take care of your shop and

the tools in it, is one of the best indications of the quality of your workmanship. It establishes your reputation. Keep your reputation good.

BE SURE YOU'RE RIGHT

Even though you're well informed about your job and the tools to use, don't hesitate to ask for help when you feel you need it. From time to time you'll be sup-

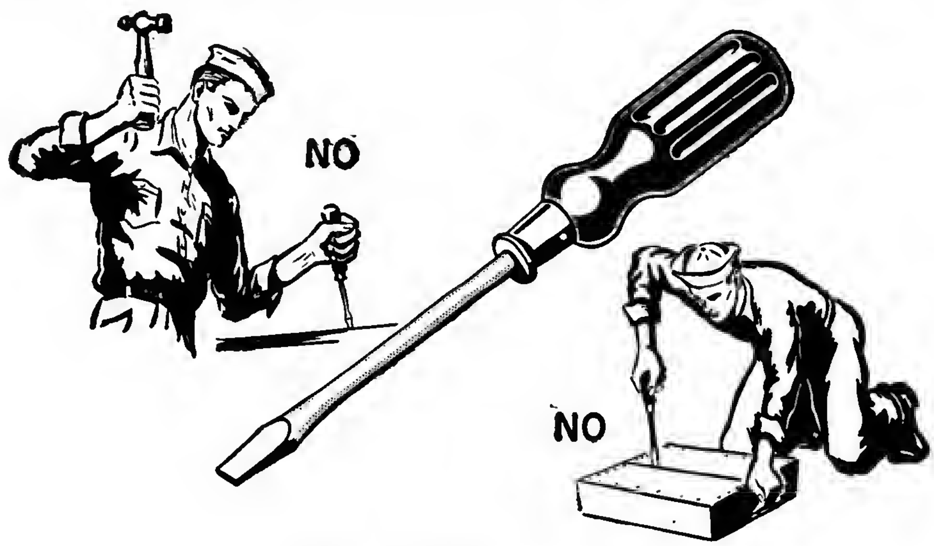


Figure 2.—It's the wrong tool!

plied with new tools and pieces of equipment. Find out all you can about them from the instructions that accompany them so they can be used to the best advantage. Before you start a job, PLAN IT OUT STEP BY STEP—on paper if necessary. Decide what tools you will need, and how you will use them to complete the job with the required accuracy in the shortest time.

DON'T MAKE MISTAKES. Your work is so important you can't afford to make mistakes. Plan your work. Pick out the right tools. Plan the procedure. BE SURE YOU'RE RIGHT, then go ahead and get the job done.

FOLLOW THE RULES. Do a careful job, keep a clean shop, and you'll feel a justifiable pride when you report.—

"Everything SHIPSHAPE, Chief."

CHAPTER 2

GENERAL-PURPOSE TOOLS

ASHORE OR AFLOAT

No matter where you're stationed—ashore or afloat—you will be using GENERAL-PURPOSE TOOLS, and you'll have them in your tool kit. They are such tools as HAMMERS, MALLETS, SCREWDRIVERS, PLIERS and WRENCHES.

They're pretty familiar to you, no doubt; but do you know all their FINE POINTS and what they can do? Even though they are common, don't take them for granted. Many people do. You may have seen workmen make a terrible mess out of such a simple task as uncrating a piece of machinery by the "bull-moose" method. But you've seen other workmen open a crate skillfully and rapidly, just because they chose the right tools and used them properly.

Avoid sloppy work. The Navy requires brains as well as brawny muscles. Just because you're dealing with simple, everyday tools, DON'T ASSUME that you know all about them. Maybe you have overlooked a few good tricks.

Most shipboard tools are used to work metal, so you may need to know more about metal-working tools than others. If you're a carpenter or patternmaker, however, pay particular attention to the chapter about wood-working tools.

Most work with tools will require an understanding of additional tools and instruments used for measuring, layout, and checking. These are described in the BASIC "USE OF BLUEPRINTS" book. You'll also find a later chapter in this book devoted to precision measuring, marking and checking tools.

HAMMERS

Whoever conceived the idea of cracking a nut with a rock unknowingly invented a tool. When a later

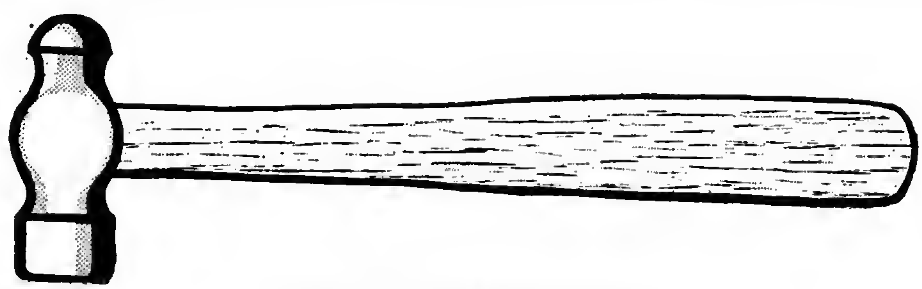


Figure 3.—Ball-peen hammer.

genius tied a stick to the rock, he invented the first hammer. There have been a lot of improvements since that humble beginning.

The METAL-WORKING HAMMERS divide themselves into two classifications—HARD-FACE and SOFT-FACE. The hard-face hammers are made of forged tool steel. One of the best general-purpose hammers is the BALL-PEEN HAMMER shown in figure 3 and often called a

machinist's hammer. The ball-shaped end is known as the peening end.

The ball-peen hammer has a couple of cousins known as STRAIGHT-PEEN and CROSS-PEEN. Both have wedge-shaped peening ends. The face end is the same for all three hammers.

Most metal-headed hammers are classed according to the weight of the hammer head, without the handle.

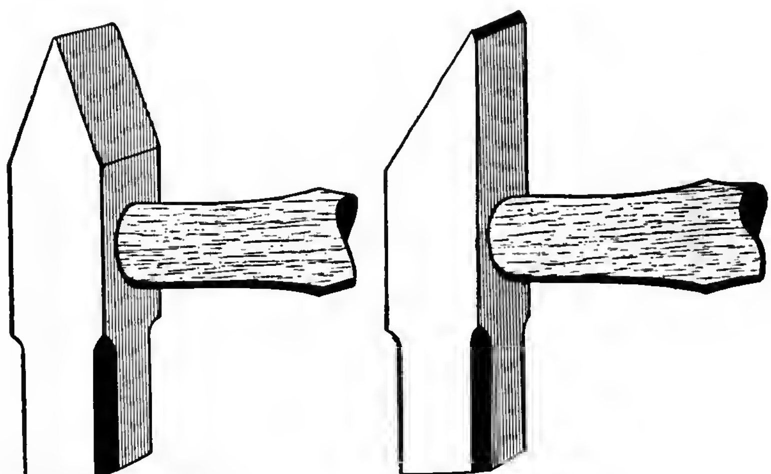


Figure 4.—Handy hammers for special jobs.

The 4-ounce and 6-ounce sizes are used for light work, such as tapping a prick punch or a small drift punch. The 8-ounce, 10-ounce and 12-ounce sizes are best for general utility work; the 1-pound and heavier types are for heavy-duty jobs. For chipping castings with a cold chisel you'll normally select the 1-pound ball-peen to pound the chisel head.

A RIVETING HAMMER is used for forming metal as well as for driving rivets. And if you're forming sheet metal seams you'll also need a SETTING HAMMER, which is designed for getting into tight corners and for forming metal at right angles. See fig. 4.

Soft-face hammers have pounding surfaces made of wood, brass, lead, rawhide, hard rubber, or plastic.

Metal workers use them to form soft metals such as copper and aluminum. In machine shops they're handy for driving close-fitting parts together or for knocking them apart. The face may be damaged easily, so DON'T USE A SOFT-FACE HAMMER FOR ROUGH WORK. It's not made for striking punch heads, bolts, or nails. One of the most practical plastic hammers is shown in figure 5. It has replaceable tips or faces.

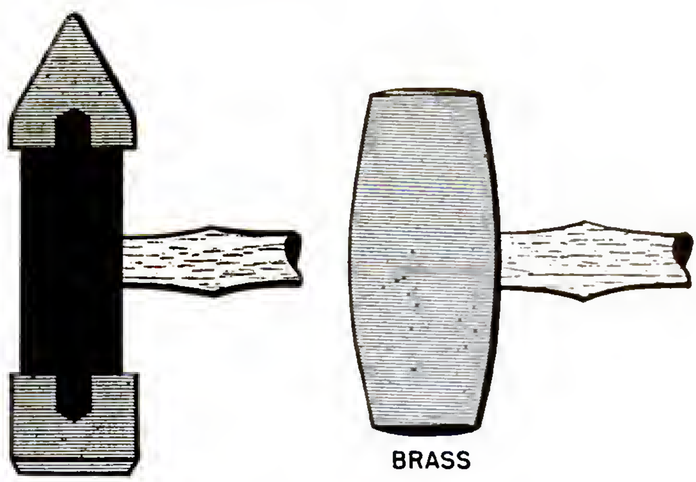


Figure 5.—Soft-face hammers.

A MALLET is a hammer-like tool made of hickory-wood, rawhide or rubber. It's used for pounding down sheet metal seams and for shaping sheet and strap metal, and it will not dent the metal as a steel hammer would. You should always use a wood mallet to pound a wood chisel or a gouge.

USING THE HAMMER

You know what happens when you "choke" a baseball bat. It reduces the power of your swing. When you grip a hammer handle too close to the head, the same thing happens. The force of the blow is reduced and it's harder to hold the hammer head in the proper position. Grip the handle close to the other end, where it's shaped to fit inside your hand.

When you use a hammer, grasp the handle as if you were shaking hands. Try it to see how well-balanced it feels. When you strike a blow, use your elbow as a pivot point—NOT YOUR WRIST. If you use your forearm as an extension of the handle, the blow will be more effective; and you'll have a better chance to strike the work squarely because the radius of your swing is longer.

Whenever possible, strike the object with the full face of the hammer, and with the hammer face parallel to the work. This spreads the force of the blow over a greater area and avoids damaging the edge of the hammer face. It also prevents unnecessary denting or marking of the stock. "Hammer-marks" are an indication of improper hammer use, and they brand the man who made them as a poor workman.

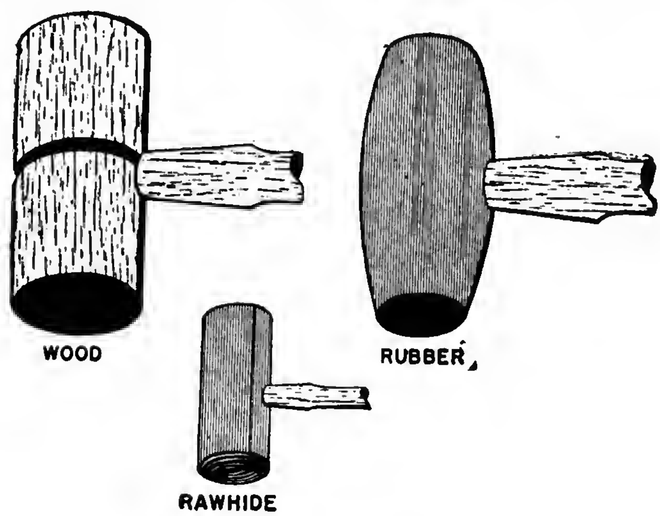


Figure 6.—Mallets.

Hammer and mallet HANDLES should be securely fastened in the EYE or hole of the head. Never work with a hammer that has a loose head. When you discover a loose head, FIX IT. If you don't, you're inviting serious injury to yourself or to a shipmate. Figure 7 shows you the kind of an accident you can avoid by exercising a little care.

Keep that handle tight. The eye (or hole) through the hammer head has a slight taper in BOTH directions from the center. After the handle is inserted in the head, drive a corrugated steel wedge in the end of the handle. This expands the wood so that it fills the eye. If the wedge comes out, or is lost, replace it before you use the hammer again.

Hammer and mallet handles are made of tough, elastic hickory. They can take a lot of hard use but

Figure 7.—A little care goes a long way.

they split easily. Don't pound with the end of the handle, and never use it for prying. It's easily broken that way.

When you need a hammer, pick out the one that's best suited for the job. Hold it properly and swing it properly and you'll do a good job. Keep your hammers clean, and every so often give them a coating of light oil to prevent rust.

SCREWDRIVERS

Screwdrivers are designed for ONE purpose—to loosen or tighten screws. Some men insist on using them as substitutes for everything from ice picks to

bottle openers. That's why you see so many screwdrivers with bent shanks or broken tips.

The bit tip or BLADE of the screwdriver is extremely hard. It has to be in order to hold its shape and resist the shearing action of the screw slot. The shank of the bit is softer and tougher than the hard brittle tip, so it can resist the twisting strain.

When the point becomes rounded or broken you can usually grind it back to its original shape. REMOVE A MINIMUM OF METAL, because you don't want to grind back past the hardened part. What's its original shape? It should look like bit tip shown in figure 8.

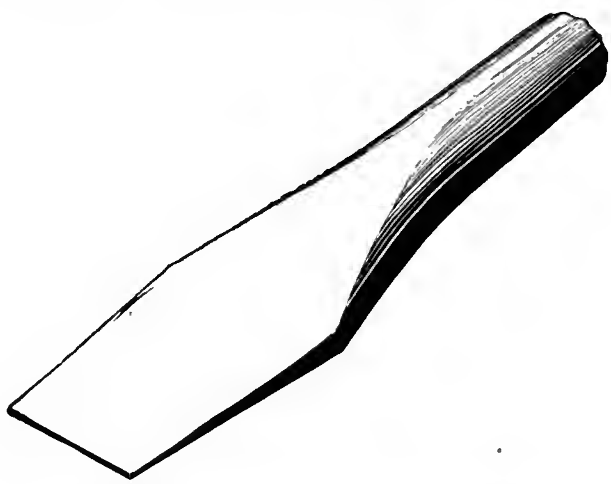


Figure 8.—Correctly ground screwdriver bit.

You can avoid most screwdriver trouble by choosing the right size and kind of screwdriver before you start to work.

The STANDARD SCREWDRIVER is obtainable in lengths from 3 to 12 inches and longer. This length is measured from the tip to the handle. For extra-heavy work there are special screwdrivers with thick, square bits. Such a screwdriver is so strong you can use a wrench to help turn it.

The PHILLIPS-TYPE screwdriver has a specially shaped point that fits Phillips-type screws only. The heads of these screws have 4-way slots that prevent

the screwdriver from slipping. Three standard sizes of Phillips screwdrivers handle a wide range of screw sizes. They do not slip easily and damage the slots or the work—IF the proper size is used. It's poor practice

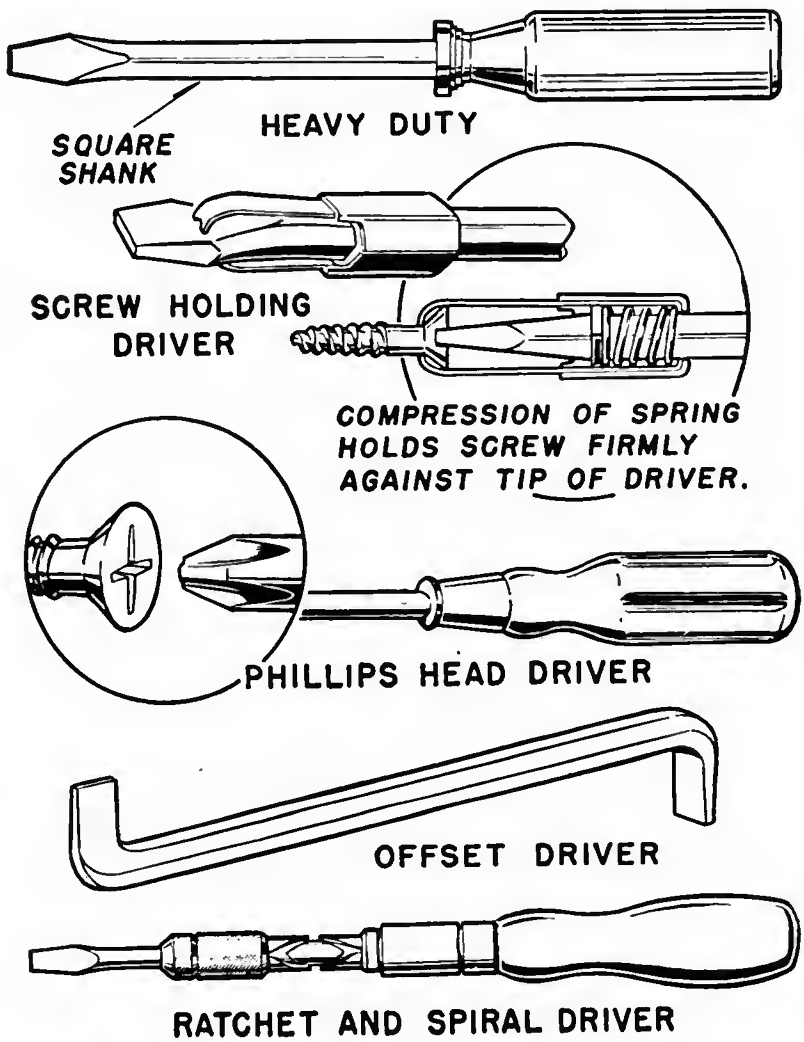


Figure 9.—Types of screwdrivers.

to try to use a standard screwdriver on a Phillips screw because both the tool and the screw slot will be damaged.

The OFFSET SCREWDRIVER is a handy tool for use in a tight spot, although it's somewhat difficult to handle because the bit has a tendency to jump out of the slot

and to burr the screw head if you're not careful. Notice that the two bit tips are made at right angles to each other. That's so you can turn the screw a quarter-turn at a time by using the opposite ends of the screwdriver alternately—if the swinging space is limited. For small screw-adjustment work in crowded, complicated mechanisms you will use a special offset screwdriver with a long handle and a bevel-gear drive. A set of assorted bits is furnished with each of these tools to fit all small screw slots.

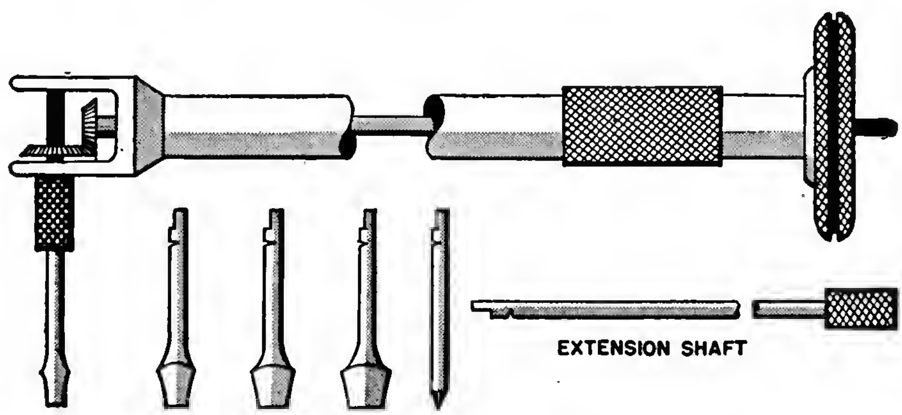


Figure 10.—Geared offset screwdriver.

Special small socket wrenches and Phillips screwdriver bits may also be used with the geared offset screwdriver.

A WORD OF CAUTION—never use a screwdriver to check an electrical circuit where the amperage is high. The current may be strong enough to arc and melt the screwdriver blade. And, never try to turn a screwdriver with a pair of pliers.

Don't hold work in your hand while using a screwdriver—if the point slips it can cause a bad cut. Hold the work in a vise, with a clamp, or on a solid surface. If that's impossible, you'll always be safe if you follow this rule. NEVER GET ANY PART OF YOUR BODY IN FRONT OF THE SCREWDRIVER BIT TIP. And that's a good safety rule for ANY sharp or pointed tool.

You probably are familiar with slip-joint pliers, commonly called COMBINATION PLIERS. They're the handymen of the plier family. You can use them to hold and bend flat or round stock, and they have an attachment for cutting wire.

Pliers are made in a range of sizes to handle a variety of jobs. The size is indicated by the overall length (usually from 5 to 10 inches). The better grades of pliers are made of drop forged steel to withstand hard usage. Plier jaws have teeth, but these teeth wear down and LOSE THEIR GRIP if used on extremely hard metal.

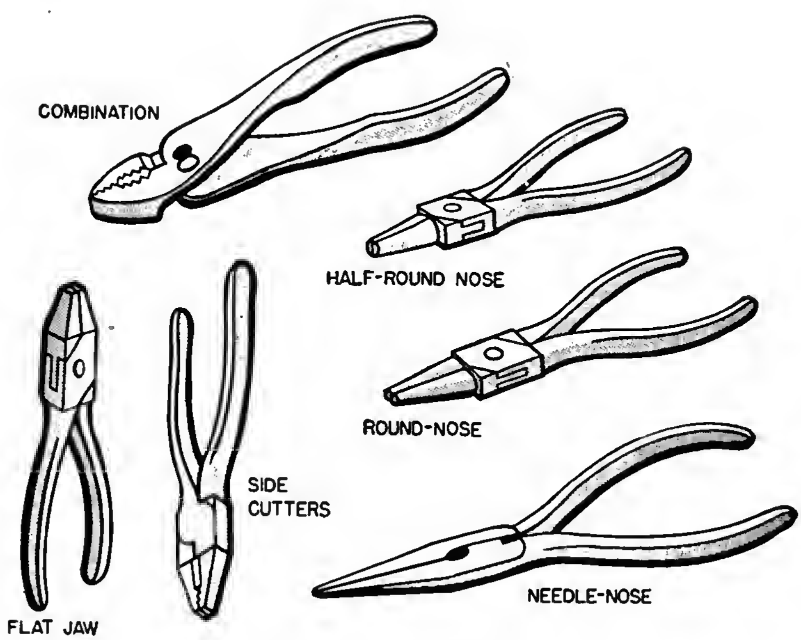


Figure 11.—Pliers.

Prominent members of this family of useful tools are the LONG-NOSE pliers. Several varieties are shown in figure 11. They may have flat, round, or half-round jaws of varying lengths. The types with long, flat tapering jaws have teeth at the inside end of each jaw. They are indispensable for holding objects in tight

spots and for making delicate adjustments. The round-nose type is used to crimp sheet metal, and to form loops in wire.

These pliers are not heavyweights, and should not be forced beyond their capacity. Their jaws are necessarily weak because they're long and therefore easily broken or sprung. Don't use pliers to turn nuts—repeat — DON'T USE PLIERS TO TURN NUTS. USE WRENCHES ON NUTS, NEVER PLIERS. All pliers should be kept clean. Every now and then wash off the dirt and grit, and oil the joint. Keep the handles clean and free of oil or grease, so the pliers won't slip and skin your knuckles.

NIPPERS

NIPPERS look like pliers, but are used only for cutting. Don't try to use them for holding. Various types

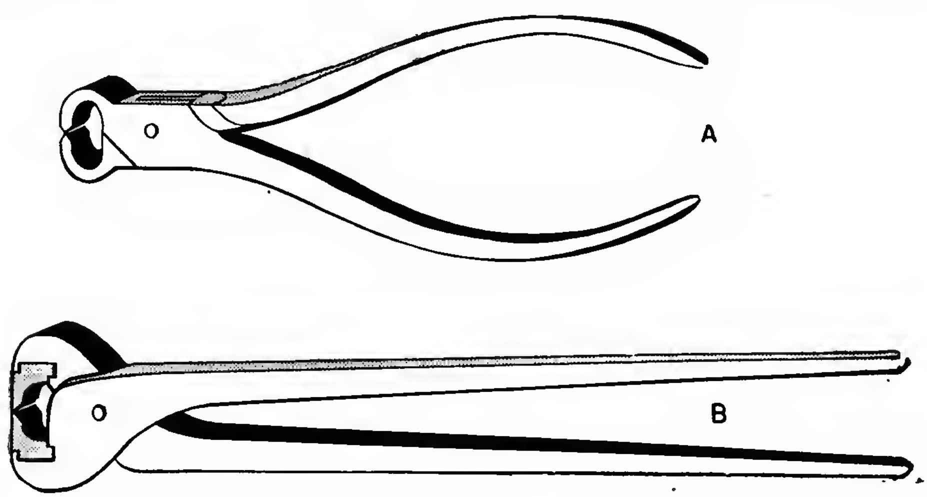


Figure 12.—Nippers.

can be used for cutting wire, rod, nails, rivets, and bolts.

For light work on soft metals you would use the nippers shown at *A* in figure 12. Don't overstrain them. Their thin cutting edges are easily nicked and dented. For heavier work, use the nippers shown at *B*.

They have replaceable blades, a strong joint, and a short fulcrum that provides plenty of leverage.

Nippers must be used carefully. It's best to consider them as emergency tools. They should never be used to cut such material as drill rod or piano wire. They can be overworked, so don't abuse them.

BOLT CUTTERS

For really tough cutting jobs, you have bolt cutters like those shown in figure 13. They are made in lengths of 18 to 36 inches. The larger ones will cut mild steel bolts and rods up to one-half inch diameter. These

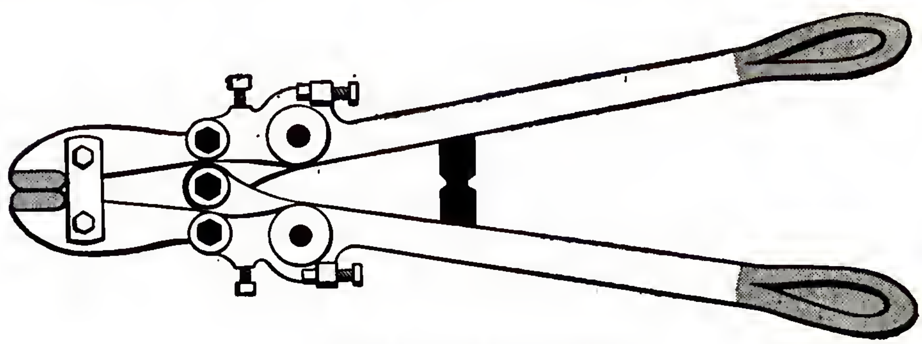


Figure 13.—Bolt cutters.

tools usually have special replaceable jaws of extra-hard metal alloys; hence, the jaws or blades are brittle and will break before they will bend or dent. Avoid any twisting motion when you use them.

DIAGONAL CUTTERS

Another useful pliers-type cutting tool is the DIAGONAL cutter. It has short jaws with blades at a slight angle, as shown in figure 14. It is ideal for removing and replacing cotter pins, and can be used not only to cut the pins to the desired length but to spread the ends after the pins are in place. Diagonal cutters are also handy for cutting the soft wire used to "safety" bolt heads and nuts.

To remove a bolt or pin that is extremely tight, start with a drift punch that has a point diameter only slightly smaller than the diameter of the object you're removing. As soon as it loosens, finish driving it out with a pin punch.

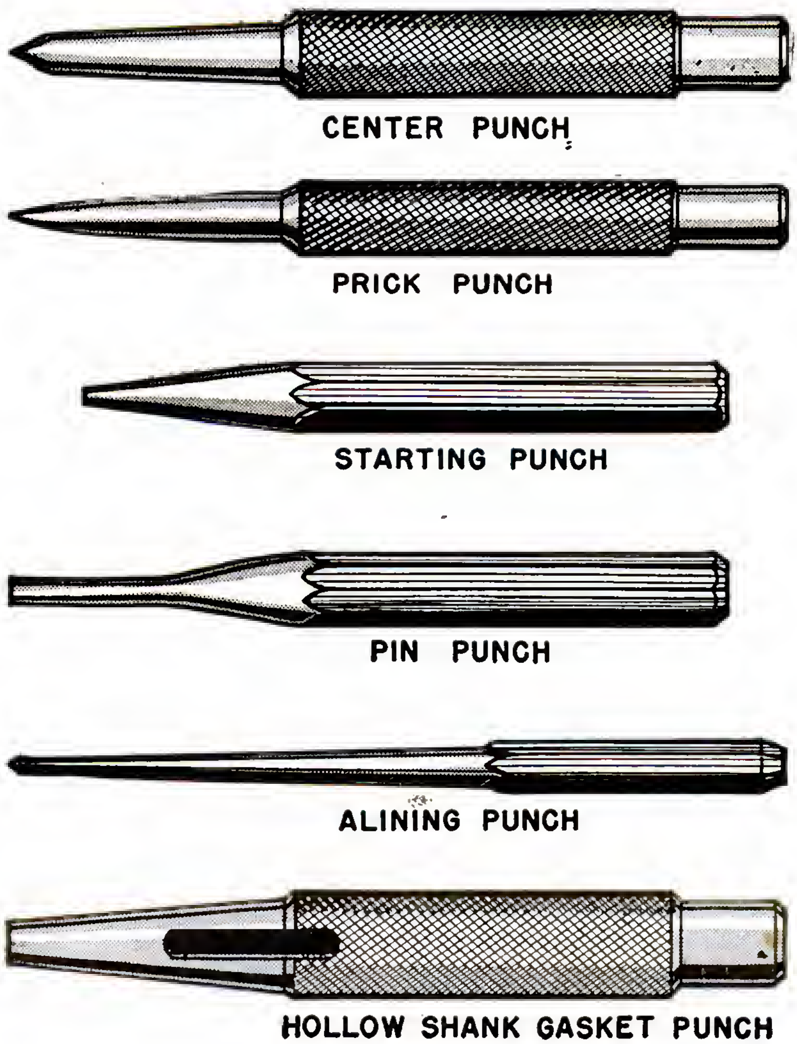


Figure 15.—Punches.

Every tool kit should contain an ALINING or "lining up" punch. It's usually 10 to 16 inches long and is used to line up corresponding holes in moving or shifting adjacent parts. It's especially handy for use on engines and other objects having pans and cover plates.

Another punch you'll use a lot is the CENTER PUNCH. A center punch MARK is used to start the drill for holes that are to be drilled in metal. If you try to drill a hole without first PUNCHING THE CENTER, the drill will "wander" or "walk away" from the desired center. Keep the center punch point taper-ground to an angle of about 90°. Never use the center punch to remove a bolt or pin by force. The sharp point will act as a wedge and tighten the bolt or pin in the hole.

Other punches have been designed for special uses. One of these is the SOFT-FACED DRIFT. It's made of brass or fiber and is used for such jobs as removing shafts, bearings, and wrist pins from engines. It's heavy enough to resist damage to itself, but soft enough not to injure the finished surfaces of the parts.

You may have to make gaskets of rubber, cork leather, or composition materials. For cutting holes in gasket materials you use a GASKET PUNCH, one type of which is shown in figure 15. This punch comes in sizes to accommodate standard bolts and studs. The cutting end is tapered to a sharp edge so as to produce clean, uniform holes. To use the gasket punch, place the gasket material on a piece of hardwood or lead so the cutting edge will not become broken or dulled. Then strike the punch with a ball-peen hammer. Drive it through the gasket where holes are required.

Another type of punch is the PRICK PUNCH. Its purpose is to mark line intersections for layout work.

VISES

THE MACHINIST'S VISE is a heavy duty HOLDING tool, and it should be used only for holding—not as an anvil. It has parallel jaws and either a fixed or swivel base. You'll use it to hold your stock when you are hacksawing, filing, drilling, tapping, reaming, etc.

The UTILITY VISE is satisfactory for general work and is designed for a variety of uses. It has a small

anvil and anvil horn as part of the back jaw. The anvil surface is broken by a small hole into which the HARDIE fits. The hardie is the small tool shown with the utility vise. It is used for cutting heavy wire and small rods and bars. PIPE JAWS are mounted inside the regular jaws for holding pipe and rods.

SOFT JAWS, inserts made of brass, copper, or other soft metal, are mounted on the jaws when the surface of your work must be protected. If soft jaws are not available you can easily make a pair out of scrap metal.

If you have to pound against metal parts held in the vise be sure you pound against the back jaw—it's

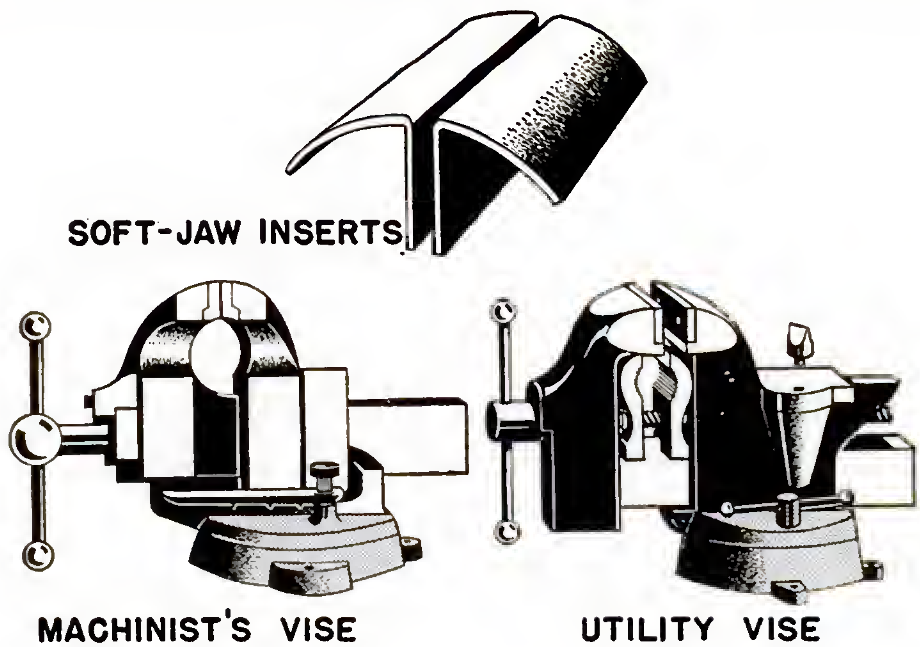


Figure 16.—Vises

heavier than the front jaw and strong enough to absorb the shock of the blows. Always tighten and loosen a vise by holding the handle with your hands and applying the weight of your body to secure turning pressure. A good workman never hammers on his vise handle because he knows it may break the sliding jaw or spring the clamping screw.

CHAPTER 3

WRENCHES

THE GREEKS HAD A WORD FOR IT

Fundamentally, the wrench is a tool used to exert a twisting strain on bolt heads, nuts, and studs. The majority of nuts and bolt heads are six-sided. A nut with 6 sides or "flats" is usually known as a HEX-NUT ("hex" being the Greek word for "six"). Most wrenches are designed to fit hex-heads and hex-nuts.

The best wrenches are made of CHROME-VANADIUM STEEL. Wrenches made of this material are light in weight and almost unbreakable. It's practically impossible to spring their jaws. They're expensive however, so the most common wrenches are made of forged carbon steel or molybdenum steel. They're strong, too, but heavier and bulkier, and their jaws are more easily damaged than those of the top-quality wrenches.

The size of any wrench used on hex-heads or nuts is determined by the size of the opening between its

jaws. Hex-nuts and heads are measured across OPPOSITE FLATS. In actual practice, you'll find that the opening of a 3/8-inch wrench will be slightly greater than 3/8 inch, so that it will be easier to slip the wrench onto the nut or head. This clearance is usually 5 to 15 thousandths of an inch, depending on the size of the wrench. Wrenches should fit snugly, with just a small amount of clearance or "play." If the wrench is a poor fit, the flats of the nut or head will be rounded and destroyed. That means trouble.

OPEN-END WRENCHES

Solid, nonadjustable, wrenches with openings in one or both ends are called OPEN-END wrenches. See fig.

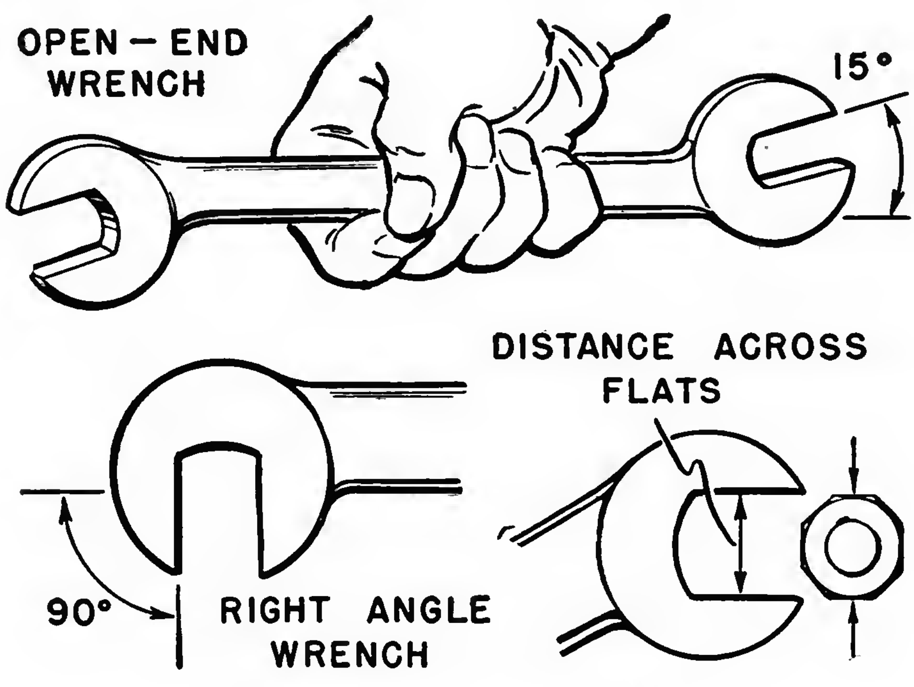


Figure 17.—Open-end wrenches.

17. They come in sets of 6 to 10 wrenches, with openings ranging from 5/16 to 1 inch. Wrenches with small openings are usually shorter than wrenches with large openings. This proportions the lever advantage of the

wrench to the bolt or stud and helps prevent wrench breakage or damage to the bolt or stud.

Open-end wrenches may have their jaws parallel to the handle or at angles anywhere up to 90 degrees. The average is about 15 degrees. Handles are usually straight, but may be curved. Those with curved han-

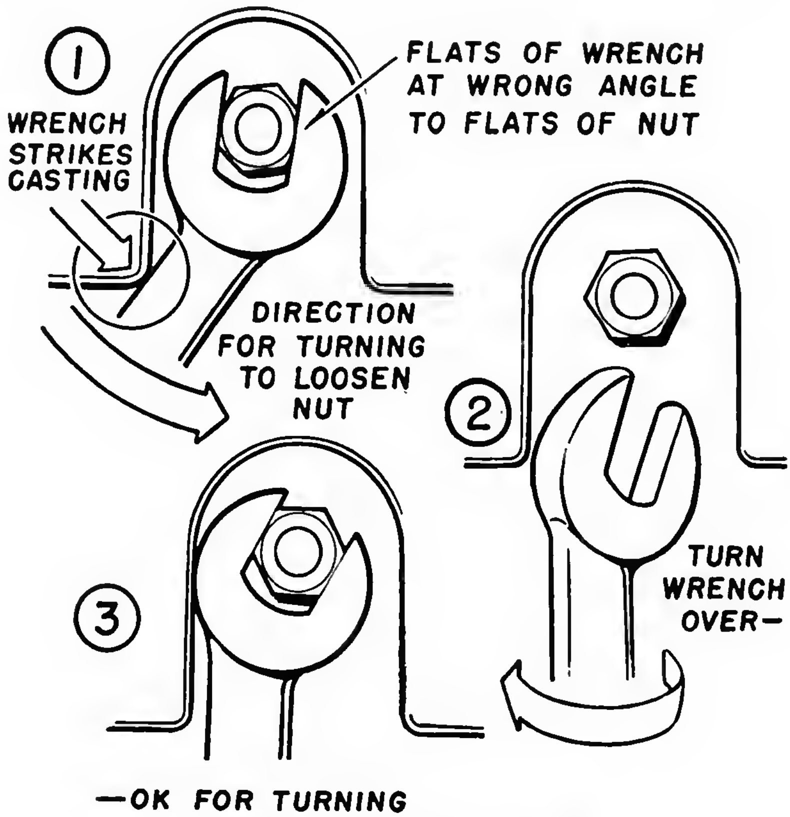


Figure 18.—Flopping procedure.

dles are called S-wrenches. Other open-end wrenches may have offset handles, to reach nuts sunk below the surface.

One of the wrenches shown in figure 17 has its jaws set at an angle of 15° with the handle and the other is a 90° wrench. The reason why the jaws are placed at an angle is obvious when you work in CLOSE QUARTERS. Suppose you are loosening a nut where there is very little space in which to swing a wrench. You will

find that by FLOPPING the wrench—turning it over so that the other face is down after each stroke—the angle of the head will be reversed and will fit the next two FLATS on the hex-nut. A 15°-angle jaw (and the flopping trick) enables you to turn the hex-nut when the swing of the wrench is limited to 30 degrees. Look at figure 18 for an example of the flopping procedure.

There are special open-end wrenches, such as TAPPET wrenches, which are very thin and have extra long handles. They are used to adjust engine valves. Handle them carefully and don't use them for other work. If you do work on engine electrical systems, you will have a set of IGNITION wrenches, sometimes called "point" wrenches. They're for adjusting the breaker points or contacts of the distributor.

The correct use of open-end wrenches is summed up in a few simple rules—

First and most important, be sure the wrench jaws FIT the nut or bolt head.

When you have to pull hard on the wrench, as in loosening a tight nut, make sure the wrench is seated squarely on the flats of the nut.

PULL on the wrench—DON'T PUSH. Pushing a wrench is a good way to acquire a set of cracked knuckles if the wrench slips or the nut breaks loose unexpectedly. If it is impossible to pull the wrench, and you must push, do it with the palm of your hand and hold your palm open. This will save your knuckles. If you cut yourself or bang your knuckles, nine times out of ten it's because you are just plain careless. There's never any excuse for that!

Only ACTUAL PRACTICE will tell you if you're using the right amount of FORCE on the wrench. The best way to tighten a nut is to turn it until the wrench has a firm, solid "feel." This will turn the nut to its proper tightness without stripping the threads or twisting off the bolt. Experience alone develops this sense of

"feel" which will enable you to tighten a nut, stud, or cap-screw to the proper degree. Practice until you KNOW you've mastered that "feel."

ADJUSTABLE WRENCHES

A handy all-round wrench for light work is the ADJUSTABLE OPEN-END WRENCH. One jaw is fixed; the other jaw is moved along a slide by a screw adjustment. The angle between the jaw opening and the handle is 22½ degrees. A wide range of sizes is provided by the adjustable feature and by the fact that wrenches of various lengths are obtainable. This tool has the disadvantage of tending to round off the corners of hex nuts, unless its jaws are closely adjusted to fit the work.

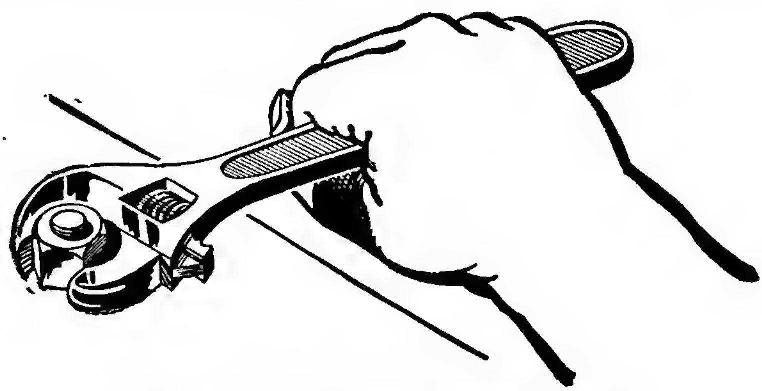


Figure 19.—Adjustable open-end wrench.

When using the adjustable end-wrench be sure to pull on the side of the handle attached to the FIXED jaw. This precaution will prevent damage to the movable jaw. You'll find this wrench valuable for making adjustments where moderate turning force is required.

You may see some adjustable open-end wrenches designed differently than the one shown in figure 19. Even though they don't look alike, they operate on the same principle and are used in the same way as the wrench shown in the illustration.

The Navy still uses some MONKEY WRENCHES like the one in figure 20. They work well on large SQUARE

the whole way off its bolt, once it's broken loose. You must lift the wrench completely off the nut after each pull, then place it back on in another position. The only time this procedure isn't necessary is when there is room to spin the wrench in a complete circle.

After a tight nut is broken loose, it can be unscrewed much more quickly with an open-end wrench than with a box wrench. This is your cue for using a COMBINATION wrench, which has a box wrench on one end and an open-end wrench on the other. A combination wrench is shown in figure 22. You can use the box

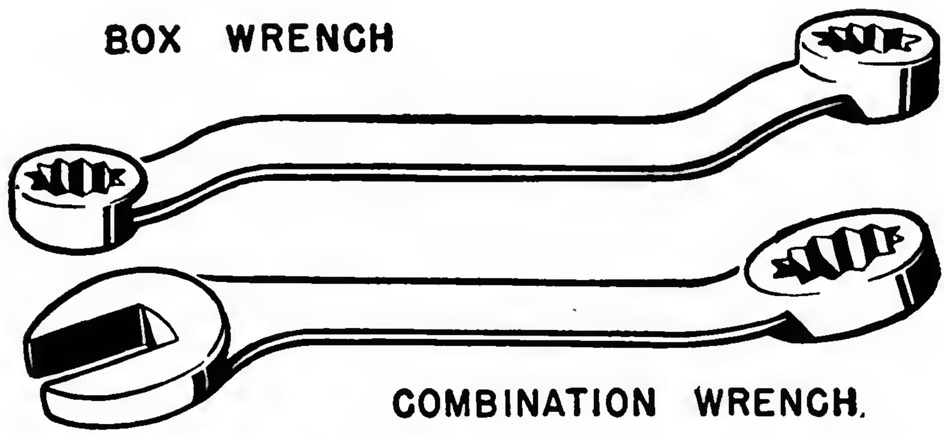


Figure 22.—Box-end and combination wrenches.

end for breaking nuts loose or for snugging them down, and the open end for faster turning.

Hammering on wrenches is strictly taboo—with one exception. There is a special type of box wrench, made strong and heavy so that you can hammer on it. The handle is short and has a steel pad on which the hammer blows are struck. This box wrench is known as a "slugging" or "striking" wrench.

For heavy duty work, there are long-handled, single box-end wrenches. They are made only in the larger sizes and you can apply all the pressure you need.

One-piece socket wrenches are made with six inside faces for hex-nuts, or with four inside faces for square nuts. They are one-piece, heavy duty wrenches and generally are made in the larger sizes. Two kinds are illustrated in figure 23, the OFFSET and the straight T-HANDLE types.

SOCKET SETS contain an assortment of individual sockets made to fit different handles. There are several

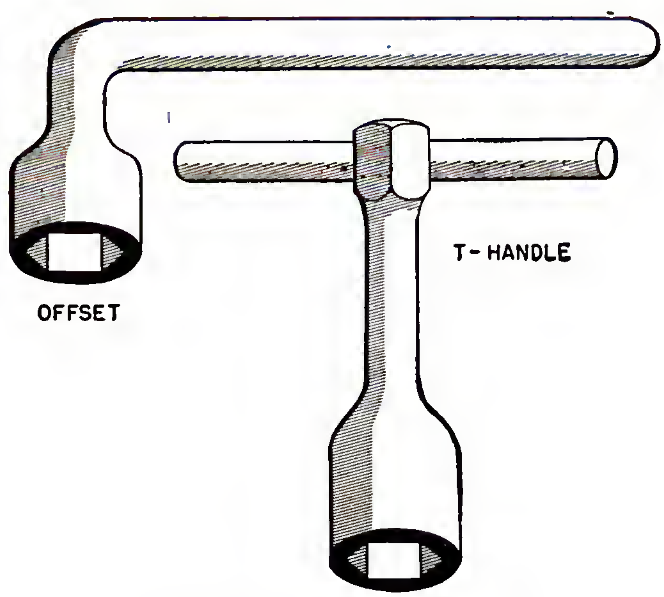


Figure 23.—Socket wrenches.

types of handles, such as the T-handle, ratchet handle, screwdriver grip handle, and a "speed" handle. The "speed" handle resembles a carpenter's brace. These handles and sockets can be assembled in combinations that will do almost any job quickly and easily.

The detachable sockets have been greatly improved over earlier types. The old sockets were large and heavy with thick sidewalls. They had to be made that way to provide sufficient strength. The opening for the

nut or bolt head was hexagonal. Socket construction was originally limited by the quality of the steel available for making them. With the new high-strength al-

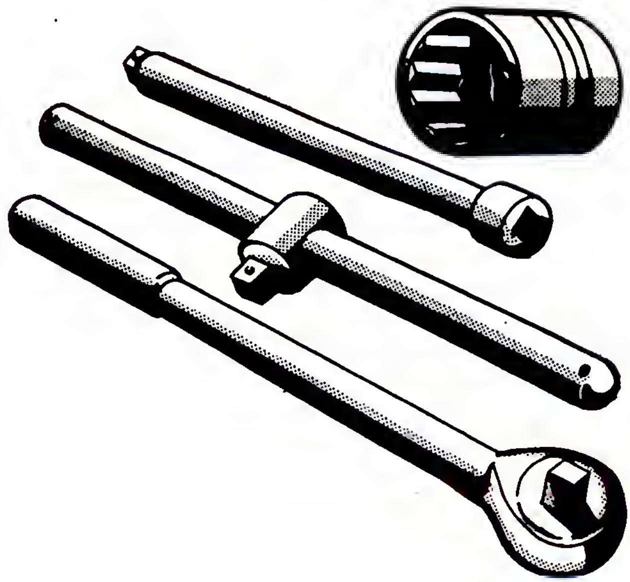


Figure 24.—Socket head and handles.

loy steels, sockets and handles are now made light and strong. The sockets now have 12-point openings and thin walls. Figure 25 shows this difference.

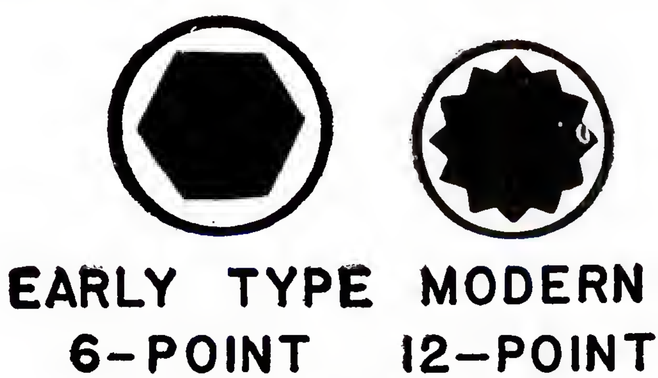


Figure 25.—The old and the new.

To use the socket wrench, select a socket head that fits the nut. Put the socket head on a suitable handle and then place it over the nut. The socket head is held on the handle lug by a small friction catch that en-

gages when the socket head and the handle are forced together.

The RATCHET HANDLE permits the wrench to be backed up without removing it from the nut. It works just like the winding stem of your watch. You can use the ratchet handle to turn the nut in either direction. If such a handle has a FIXED lug, it will have a "gear-

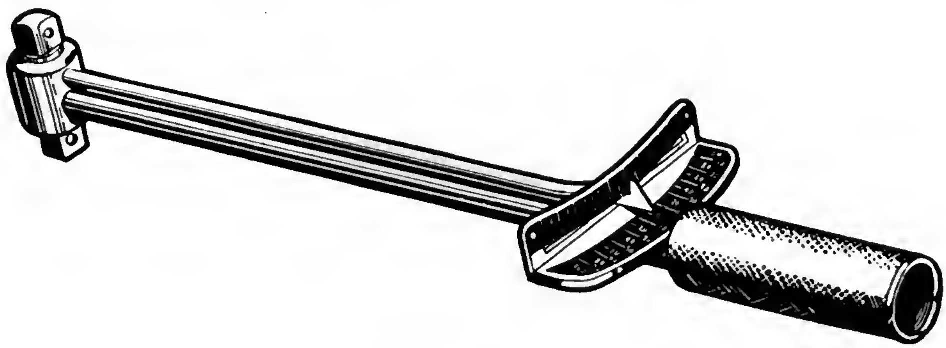


Figure 26.—Torque wrench.

shift" to change the direction. If the lug is REMOVABLE, the working direction can be changed by inserting the lug on the opposite side of the handle.

Elaborate socket-wrench sets contain extension bars, T-handles, L-handles, speed handles or "spinners," and universal joints. Special deep sockets can be obtained for removing or tightening spark plugs and for use where the nut is a long way down on the bolt.

Another accessory for the socket-wrench set is the TORQUE WRENCH, shown in figure 26. Torque is the result of a turning or twisting force exerted on a wrench. The torque wrench indicates on a scale or dial how great a twist is being exerted, and is used for the final tightening of nuts and studs to prevent twisting them in two or stripping the threads, while yet tightening them to the proper degree.

The accuracy of a torque wrench reading depends on the accuracy of the threads on the bolt or nut, and the type and amount of lubrication. Readings are

MORE accurate when the threads are lubricated.

Socket sets, if not misused, can be depended upon to give long service. The important thing to remember is that socket heads and handles should not be overstressed. Never use a bar or pipe to increase the leverage. And keep all parts clean and free from rust.

KEEP A CLOSE TAB ON THOSE SOCKET HEADS. They get lost or misplaced easily. This is especially true of the small size sets used by radio technicians and repairmen.

SPANNER WRENCHES

The British call most of their wrenches "spanners". However, SPANNER WRENCHES, as they're known in

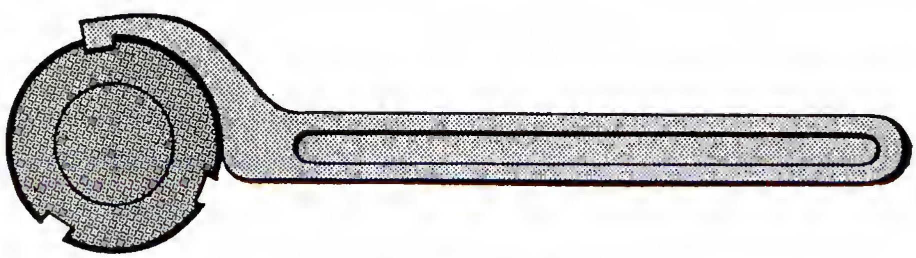


Figure 27.—Hook spanner.

the United States, are special wrenches for special purposes. There are a number of types. The HOOK SPANNER works on a round nut which has a series of

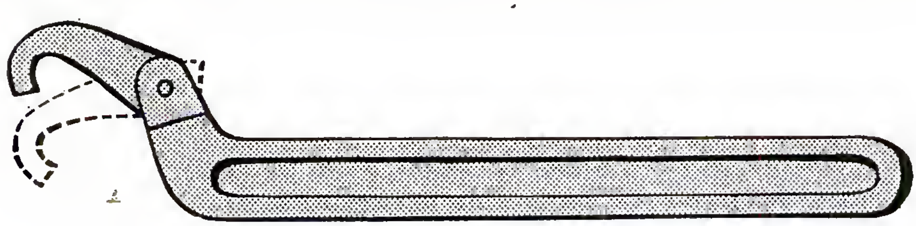


Figure 28.—Adjustable hook spanner.

notches cut in its outer surface. The hook (or lug) is placed in one of these notches and the handle turned to loosen or tighten the nut. Figure 28 shows an ADJUSTABLE type of spanner, designed to fit nuts of various diameters. PIN SPANNERS have a pin instead

of a lug. The pin fits a round hole in the edge of the nut. U-SHAPED HOOK SPANNERS have lugs that fit in

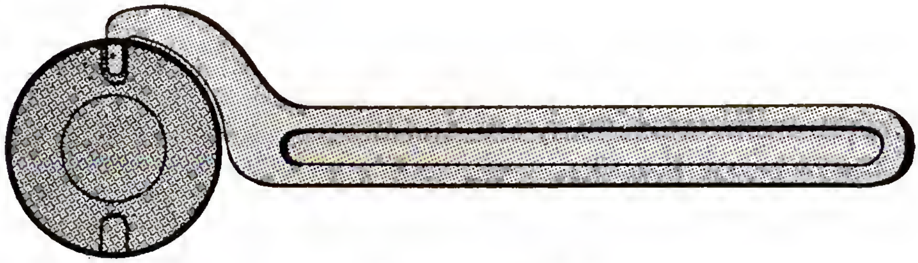


Figure 29.—Pin spanner.

notches cut in the TOP of the nut or screw plug. FACE PIN SPANNERS serve the same purpose except that they have round pins instead of lugs.

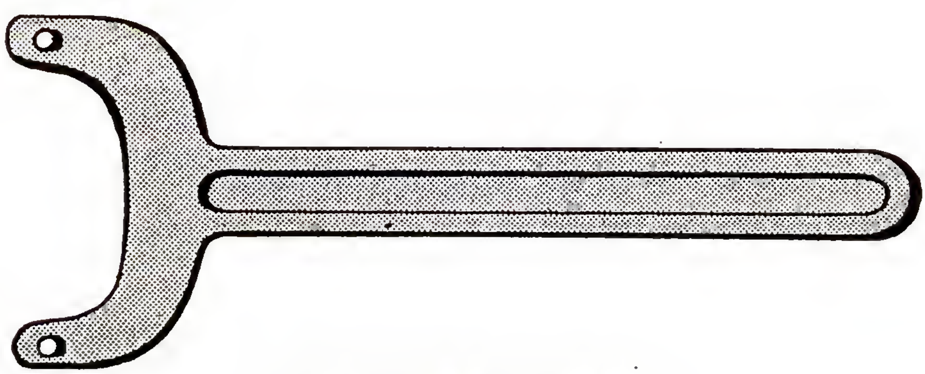


Figure 30.—Face pin spanner.

SPECIAL WRENCHES

Figure 31 shows the ALLEN-type wrench. Its six-sided shaft fits into the hollow hex-shaped recess of set screws and cap screws. This wrench comes in sizes from 1/8 to 3/4 inch. You must use the right size to prevent spreading the slot.

The BRISTO-type wrench eliminates the spreading action by using a number of splines. These are shown in the end view of the Bristo wrench in figure 31.

The SPINTITE wrench, figure 32, has a hollow shaft with a hex-head, and is used like a screwdriver. It is

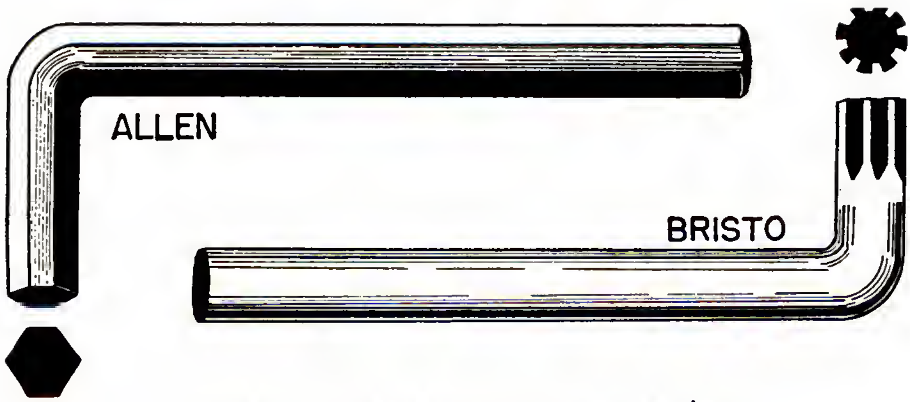


Figure 31.—Allen and Bristo type wrenches.

used for electrical work and is usually supplied in small sizes only. It should have an INSULATED HANDLE.

Figure 32.—"Spintite" wrench.

The DIAL wrench, figure 33, is a special wrench for

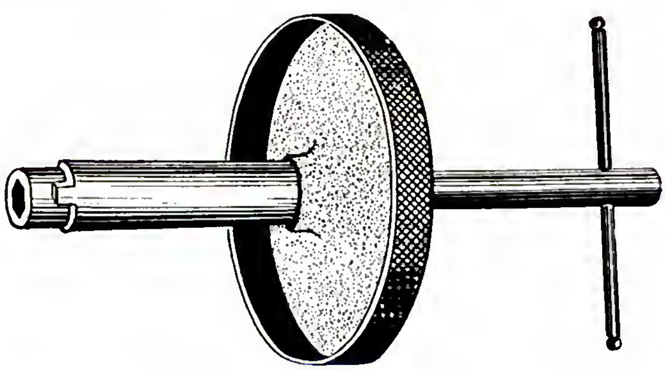


Figure 33.—Dial wrench.

removing and replacing the dials of electrical and computing equipment.

RULES FOR WRENCHES

REMEMBER—

Use a wrench that fits the nut exactly.

Keep wrenches clean and free from oil. Otherwise they may slip, resulting in possible serious damage to parts or to YOU.

Don't increase the leverage of a wrench by placing a pipe over the handle. Increased leverage may damage the wrench or the work.

Provide some sort of kit or case for all wrenches. Return them to it at the completion of each job. This saves time and trouble and facilitates selection of tools for the next job. Most important, it eliminates the possibility of leaving them where they can cause damage to equipment.

Determine which way a nut should be turned before trying to loosen it. Most nuts are turned counterclockwise for removal. This may seem obvious, but even experienced mechanics have been observed straining at the wrench in the tightening direction when they wanted to loosen it. Check to be sure of your direction.

Learn to select your wrenches to fit the type of work you're doing. If you're not familiar with these wrenches, make arrangements to visit a shop where they have most of them, and get acquainted.

CHAPTER 4

METAL-CUTTING TOOLS

HAND SNIPS

SNIPS do just what their name implies—they snip or cut off pieces of metal. They are, in fact, one form of hand shears. The STRAIGHT SNIPS seen in figure 34 have blades that are flat and straight on the inside surfaces. These snips are designed for straight cutting, but they'll also do a good job on large outside curves.

It's a tough job, however, to cut circles and arcs of small radii with straight snips. Those illustrated in figure 35 are specially designed for circular cutting.

The SCROLL-PIVOTER snips can be used to cut out small arcs and circles, or sharp irregular curves. The blades are approximately at right angles and provide clearance for following curves. They also can be used for straight cutting.

The CIRCULAR snips, with their curved blades, will handle any curves except the smaller ones.

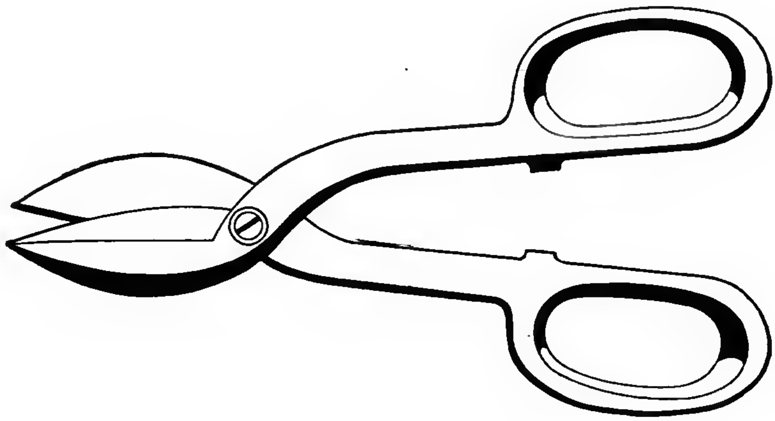


Figure 34.—Straight snips.

The HAWKBILL snips are particularly useful in making curved cuts in large sheets. These snips, as well as the circular ones, must be used carefully because the blades are easily sprung out of contact.

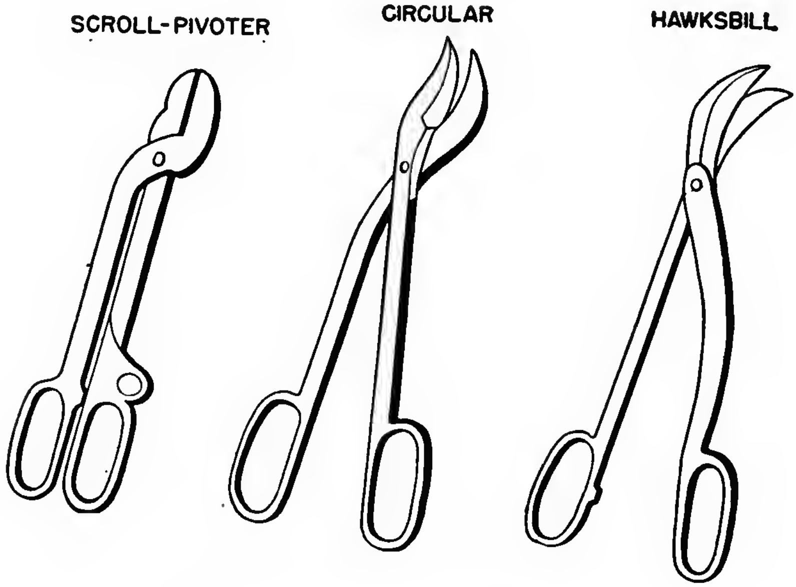


Figure 35.—Snips for small curves.

Still another group of snips is known as COMBINATION SNIPS. The advantage of combination snips is

that they can be used for several types of work and, therefore, only one pair of snips need be carried around to handle the average metal-cutting job.

The best known of these combination snips are the "TROJAN" snips. You'll find them illustrated in figure 36. They are rugged tools and should be used for heavier curved cuts.

Special snips are designed for stainless steel and Monel metal. They resemble the Trojan snips, but have inlaid alloy cutting edges. They'll have "For Stainless Steel Only" stamped on their handles.

REMEMBER THIS.—Don't use regular snips on stainless steel and don't use the special stainless steel snips to cut brass, tinplate, copper or sheet iron.

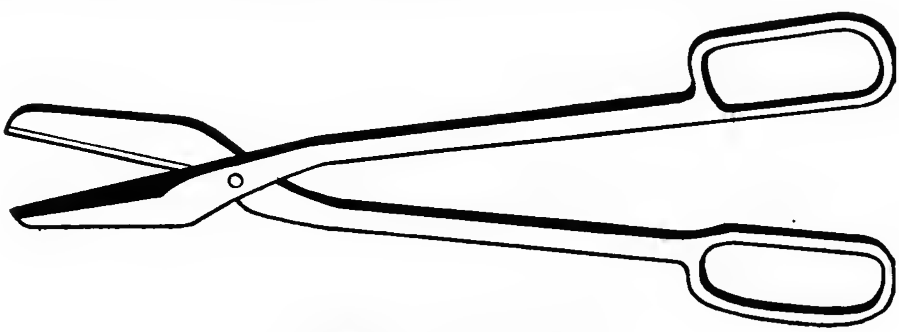


Figure 36.—"Trojan" snips.

Snips do not remove any of the metal. They cut with a SHEARING ACTION that tends to mash and roughen the edges of the cut. Because the sheared edge is rough, you must cut OUTSIDE THE LINE and dress the edge with a file. Exception—if the metal is very thin you can cut ON the line.

When you're trimming the edge of a large sheet, you'll have better luck if you cut from the left-hand side. This allows the small piece being removed to curl out of the way of the snip blades as the cut is made.

Never cut with the full length of the blades. If the points of the snips are allowed to come together they will tear the metal sidewise where they meet. Stop each cut about ¼ inch before the ends of the blades

have been reached and start a NEW cut with the THROAT. The throat is that part of the angle between the blades nearest to the pivot pin. By cutting from the throat you get more leverage and less blade spread than you get if you work nearer the points.

Most snips for shop use are from 12 to 14 inches long, but tool kits may contain snips as short as 6 inches. You may also use other snips, especially some of the new types of combination snips.

Hand snips will withstand a lot of hard use BUT there's a limit to their endurance. NEVER USE SNIPS TO CUT WIRE, BOLTS, RIVETS, OR NAILS. Such use will dent or nick the cutting edges. Snips are strictly sheet metal tools, and even they shouldn't be used on sheet metal heavier than 18-gage.

Snip blades can be reground when they become dull. The cutting edges should be ground to an included angle of 85°. Take the two blades apart and you'll find the grinding a lot easier. Snip blade tension is adjusted by turning the nut on the pivot bolt or pin. The blades should be just tight enough to remain in any position in which you place them. For easy operation keep the pivot well oiled. Oil the blades with a thin film of light machine oil to prevent rust. Keep the snip blades closed when they're not in use.

Here's a tip. When you're cutting large sheets or other flat stock, lay the stock on the bench and make the cut with the lower handle of the snips resting on the bench top. This lessens the strain on your hand and allows you to use your weight to advantage.

When you have your stock cut out, put your snips away. Then, reach for a file and REMOVE THOSE ROUGH BURRS on the edges of the metal.

HACKSAWS

If the metal is too thick or too hard to cut with snips, you'll find that a HACKSAW will do the job. The com-

mon hacksaw has a BLADE, a FRAME, and a HANDLE. The PISTOL-GRIP type in figure 37 is adjustable to take various blade lengths. The STRAIGHT-HANDLED job shown is not adjustable although the Navy does use some straight-handled, adjustable hacksaws.

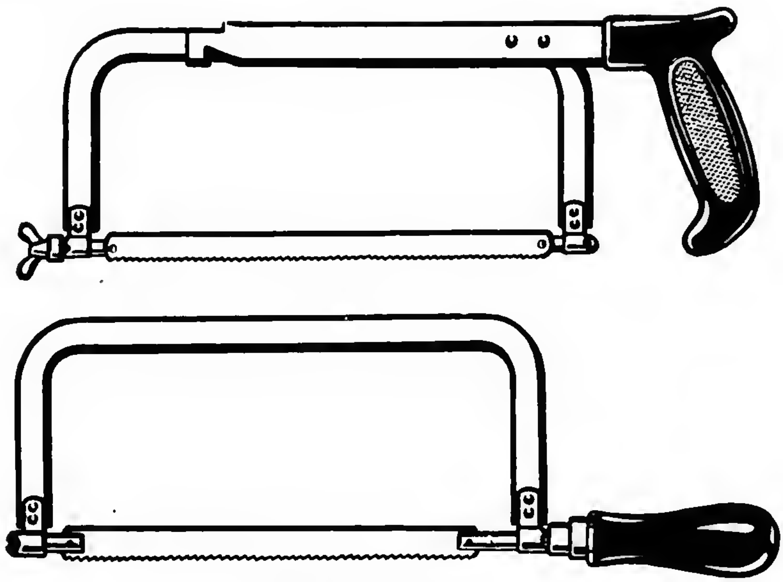


Figure 37.—Hacksaws.

Hacksaw blades have holes in both ends. They are mounted on the frame by means of PINS attached to the frame. There's only one RIGHT way to mount a hacksaw blade. Many a good workman has made the mistake of putting the blade in backwards. Don't you make the same mistake. Always mount the blade with the teeth pointing AWAY from the handle. For ease in mounting, put the blade on the back pin first. Tighten the blade with enough tension to hold it rigidly between the pins, and then the tool is ready.

Make sure you select the proper blade. Blades are made of high-grade tool steel or tungsten steel, and are available from 6 to 16 inches in length. The 10-inch blade is the one that's used the most. There are two types—the ALL-HARD blade, and the FLEXIBLE blade. Only the TEETH of the flexible type are hardened. Selecting the best blade for a job is a question of finding

one of the right type and pitch. An all-hard blade is best for sawing brass, tool steel, cast iron, rails and heavy cross-section stock. A flexible blade is usually best for sawing hollow shapes and metals having a light cross-section.

The PITCH of a blade indicates the number of TEETH it has per inch. Pitches of 14, 18, 24 and 32 are available. Figure 38 gives you an idea of how to go about selecting the right pitch for a particular job. You

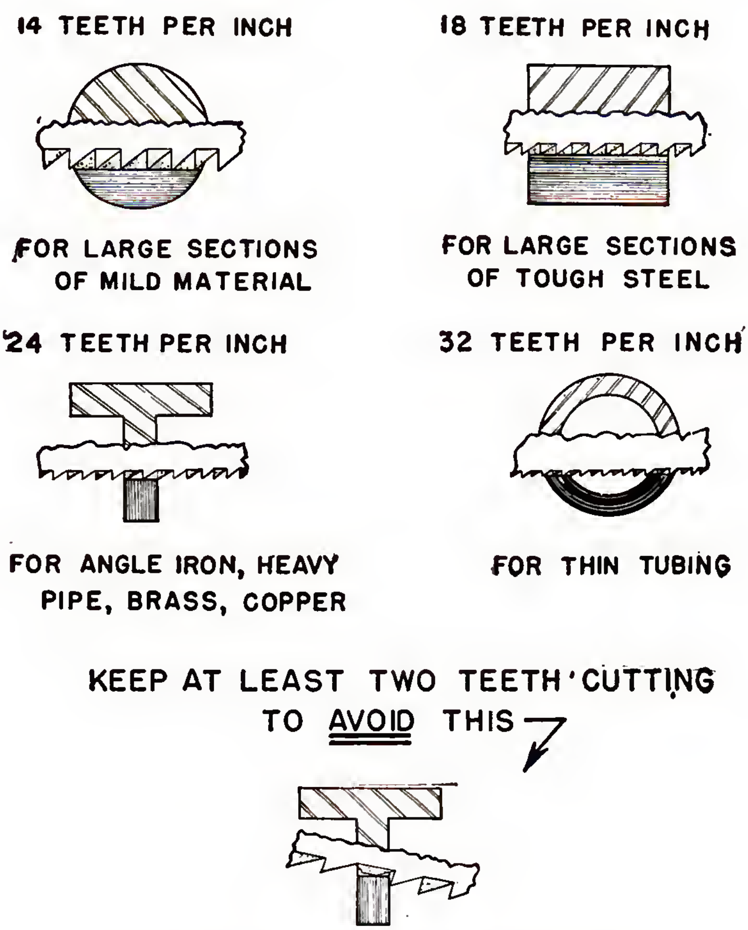


Figure 38.—Use the correct pitch of blade.

should use a blade with 14 teeth per inch on machine steel, cold-rolled steel, or structural steel. It will cut fast and free. Use the 18-pitch blade on solid stock of aluminum, bearing metal, tool steel, high speed steel,

cast iron, etc. This is the blade pitch for general purpose work.

Use a blade with 24 teeth per inch for cutting thick-wall tubing, pipe, brass, copper, channel, and angle iron. Use the fine tooth, 32-pitch blade for thin-wall tubing and sheet metal.

You must also consider the SET when you select the blade. "Set" means simply that some teeth are pushed

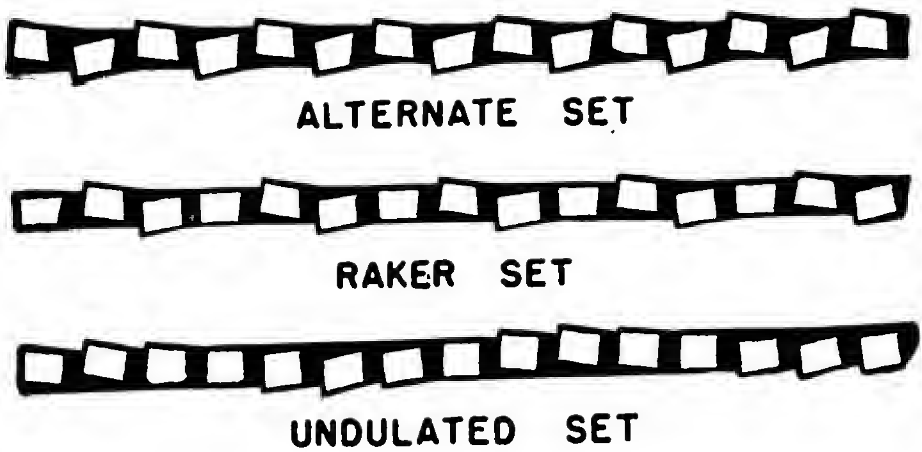


Figure 39.—"Set" of hacksaw blade teeth.

sideways in one direction and the same number in the opposite direction, according to definite patterns. The set provides CLEARANCE for the blade so it won't jam and stick, and it prevents overheating the blade. The blade is only .025 inch thick but the set causes it to make a cut about TWICE that wide. Three types of set are illustrated in figure 39. The one labeled "undulated set" is more commonly called "wave" set and you can see why. It's used for the fine-toothed blades.

USING THE HACKSAW

Before you start a hacksaw cut, check again to see that you have the proper blade, and that its teeth point AWAY FROM THE HANDLE. Check and adjust the blade tension, and your hacksaw is ready.

Secure the stock in a vise, or with clamps, if it's not already anchored to something. It must be held firmly to prevent the blade from "chattering" and twisting. Saw alongside a scribed line and stay just OUTSIDE that line. The blade will start more easily if you file a V-shaped nick at the starting point. Hold the saw at an angle that will keep at least two teeth cutting all the time—otherwise the blade will jump and individual teeth will be broken. Figure 40 shows the right and wrong angles for cutting.

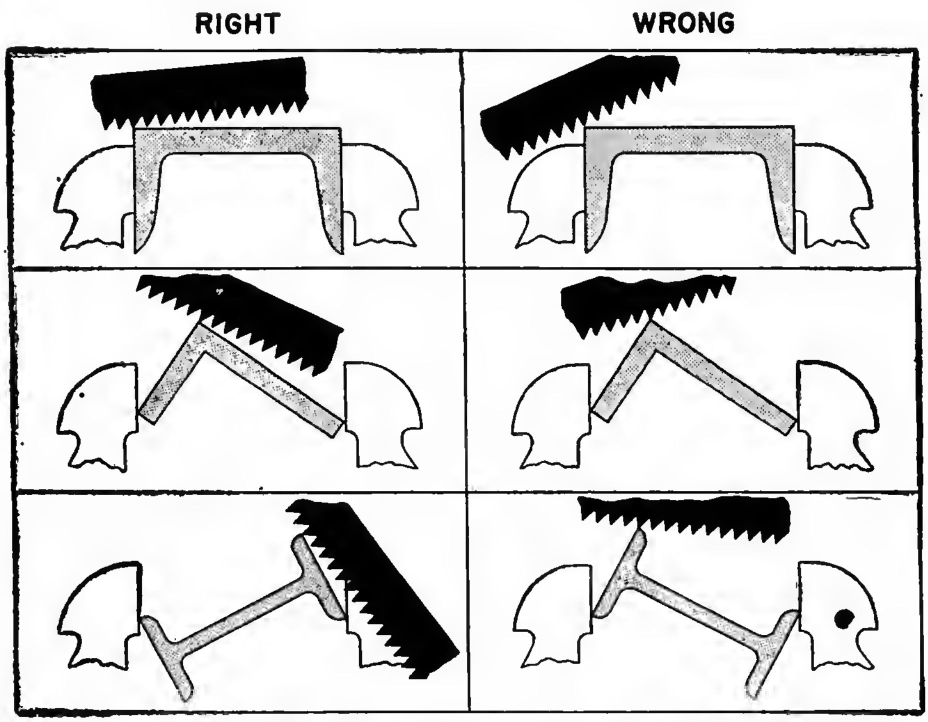


Figure 40.—Starting hacksaw cuts.

Start the cut with a light, steady, FORWARD stroke. At the end of the stroke, relieve the pressure and draw the blade STRAIGHT BACK.

After the first few strokes, make each one as long as the hacksaw frame will allow. If you don't, the middle teeth will wear rapidly and overheat. Use just enough pressure on the forward stroke to make each tooth remove a small amount of metal. Don't use ANY pressure on the BACK STROKE. Remember that the

teeth POINT FORWARD, and that the forward edges do the cutting.

After the cut is started, use long steady strokes and do NOT SPEED—hold the pace down to 40 or 50 strokes per minute. That may seem slow but if you go too fast the blade will get hot, the teeth will round off and "lose set," and you'll have difficulty sawing straight. You may even break off some of the teeth or cramp the blade and break it. And when you examine the cut, you'll find it is ragged and crooked. So TAKE IT EASY—about 90 percent of hack-sawing trouble is caused by too much speed.

As you near the end of the cut slow down still MORE, so you can control the saw when the stock is sawed through.

If you watch an experienced mechanic using a hacksaw, you might think him pretty slow. Don't be

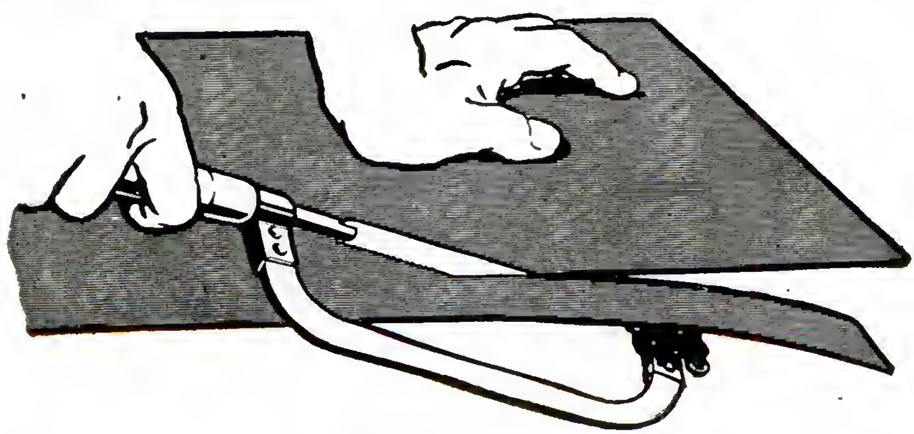


Figure 41.—Cutting deep.

deceived. He's just going about his work the RIGHT WAY. You will see him clamp his stock securely in the vise, place his feet "just so" (with the left foot slightly forward), and stand erect as he works. He will use long, smooth, straight sawing strokes with an easy rhythm of arms and body, and saw the stock in two in a surprisingly short time.

When he finishes using the saw you'll see him clean the chips from the blade, loosen the tension, and return the hacksaw to its proper place.

Figure 41 shows you how to make a long cut along the side of a piece of metal stock. Notice that the blade has been turned so it is at right angles to the frame, which makes it possible to saw a cut deeper than the saw frame would otherwise allow.

FLAT COLD CHISELS

If you can't use snips or a hacksaw for cutting, reach for a FLAT COLD CHISEL. It's your metal-cutting troubleshooter. It can be used in restricted areas, and for such jobs as shearing off rivets, smoothing castings, or splitting rusted nuts from bolts. A cold chisel cutting edge will cut any metal softer than itself.

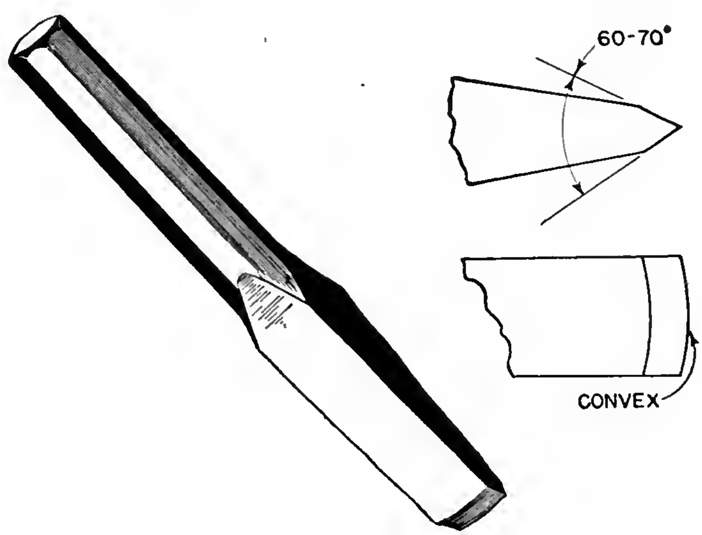


Figure 42.—Flat cold chisel and point angle.

The size of a flat cold chisel is determined by the width of the cutting edge. Lengths will vary, but these chisels are seldom under 5 inches or over 8 inches long. Chisels are usually made of octagonal (eight-sided) tool steel bar stock, carefully hardened and tempered. Notice that the cutting edge of the chisel shown in

figure 42 is slightly convex (curved outward). This causes the center portion to receive the greatest shock, and protects the weaker corners. The point angle should be 60-70 degrees for general use.

The cold chisel may be used to cut wire, strap iron, or small bars and rods. For this type of work, place the stock to be cut on a soft steel plate—not on the vise or anvil. Hold the chisel vertically, with the cutting edge on the cut-off line. Wrap the fingers of your holding hand around the chisel and grip with the two

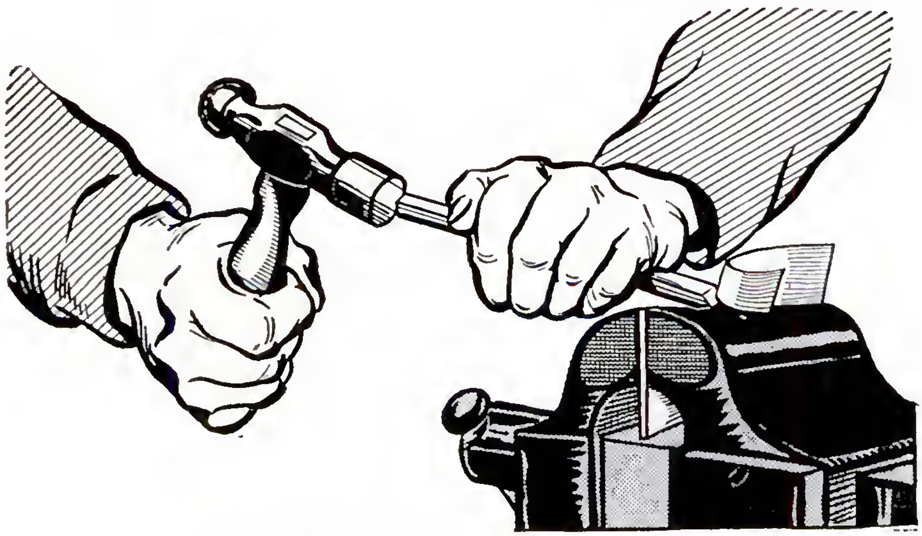


Figure 43.—Shearing with the cold chisel.

lower fingers, very much like the man holding the chisel for shearing in figure 43. Then strike the chisel head with a suitable ball-peen hammer. KEEP YOUR EYE ON THE CUTTING EDGE—not on the chisel head or on the hammer.

SHEARING is best done by clamping the stock in the vise, and "slicing" it with the chisel held at an angle. This works even better if the metal is placed between two pieces of angle iron and the whole set-up clamped solidly in the vise. The angle iron then protects the tops of the vise jaws.

Chipping is the term applied to a method of removing metal from a surface with a chisel. It's very much like chipping off old paint, except that you're cutting off the metal itself. Figure 44 shows how the chisel should be sharpened and directed for chipping.

In chipping steel, lubricate the chisel point with light machine oil. This will make the chisel easier to drive, and cause it to cut faster than it would if dry. Don't use oil on cast iron—it causes the surface to glaze. Cast iron should be chipped from the edge, to avoid breaking off the edges and corners. When you're chipping, protect your eyes with goggles, and shield the area so chips can't strike anybody.

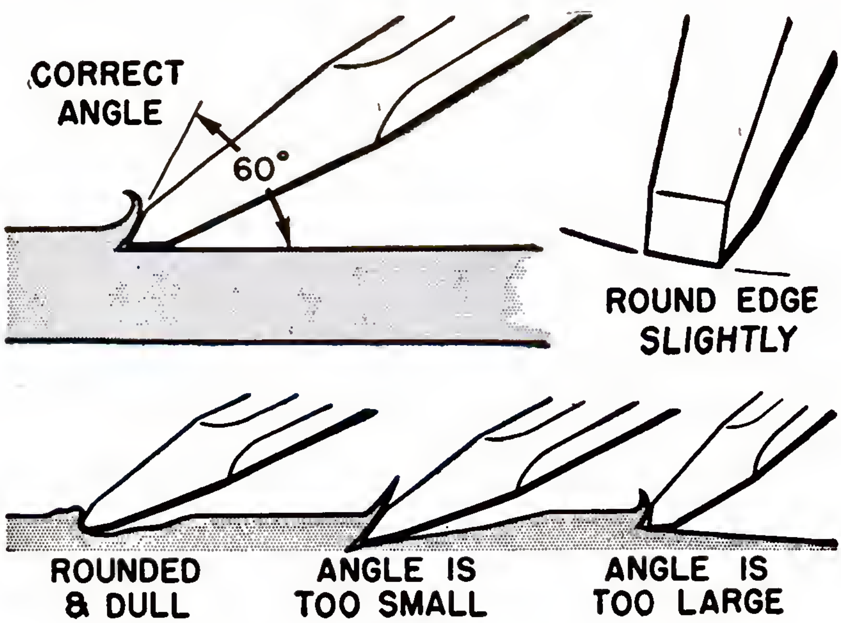


Figure 44.—Results of correct and incorrect chisel grinding.

Keep your chisel sharp and the edge ground at the proper angle (60-70 degrees). When grinding the chisel, hold it against the wheel with very little pressure so as to avoid overheating. Dip the point in water often enough to keep it cool. Otherwise, the heat generated will "draw" the temper of the steel. If this happens, the cutting edge will become soft and useless until rehardened and tempered.

Blows of the hammer will cause the head of the chisel to spread out until it looks like a ragged mushroom. This spread-out head is rough, and will "ream out" the inside of your hand if the chisel slips. Also,

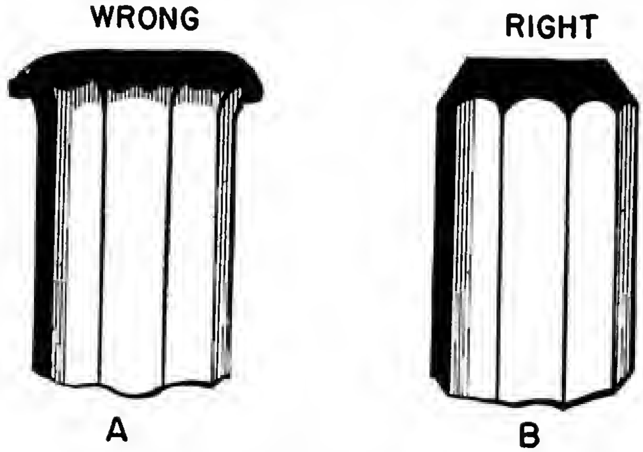


Figure 45.—Grind off those mushrooms.

chunks may break away from the overhanging mushroom with enough force to cause injury. So keep the head ground down to look like *B* in figure 45—don't ever leave it looking like *A*.

SPECIAL COLD CHISELS

If your work involves cutting keyways, square cor-

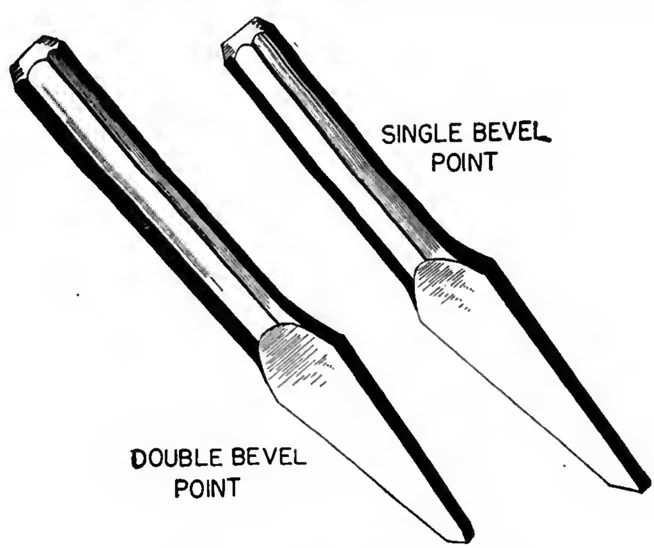


Figure 46.—Cape chisels.

ners or slots, use the CAPE chisel. It's like a flat chisel except that the cutting edge is very narrow. It has the same point angle (60 to 70 degrees) and is held and used in the same manner. Two types are shown in figure 46.

Rounded or semi-circular grooves, and corners which have fillets, should be cut with the ROUND-NOSE chisel. This chisel is also used to "draw back" a drill which has "walked away" from its intended center.

The DIAMOND-POINT chisel is tapered square at the

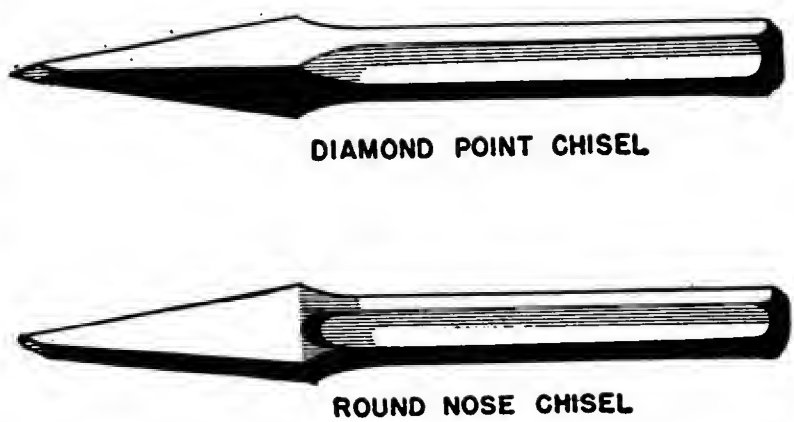


Figure 47.—Special cold chisels.

cutting end, then ground at an angle to provide the sharp diamond point. It's used for cutting V-grooves and inside sharp angles.

FILES

Your tool kit will include an assortment of files. They are used for cutting, smoothing, or removing small amounts of metal. They vary in length, shape and cut of teeth to provide files for various uses. Files are fitted with removable handles, and it's dangerous to use one WITHOUT a handle. The terms commonly used to describe a file are shown in figure 48.

In selecting a file for a job, consider its SHAPE. This means both the outline and cross-sectional shape. Some

of the cross-sectional shapes are shown in figure 49.

TRIANGULAR, or "three-square" files are tapered on all three sides. They are used to file cutters, acute in-

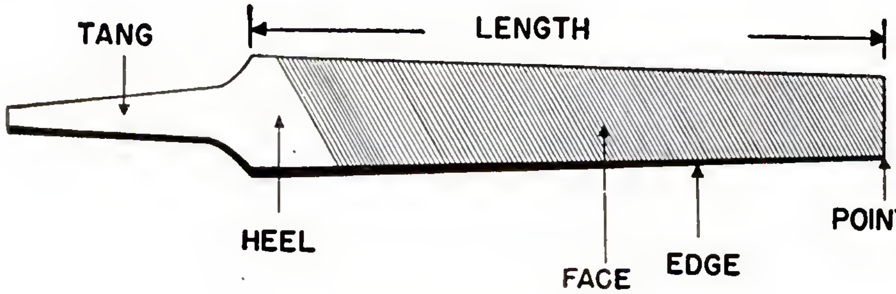


Figure 48.—File terminology.

ternal angles, and to clear out square corners. Special triangular files are used to file saw teeth.

MILL files are tapered in both width and thickness. One edge has no teeth and is known as a SAFE EDGE. You use mill files for lathe work, drawfiling, and other fine, precision work. Mill files are ALWAYS SINGLE-CUT.

FLAT files are general purpose files and may be either single or double-cut. They are tapered in width

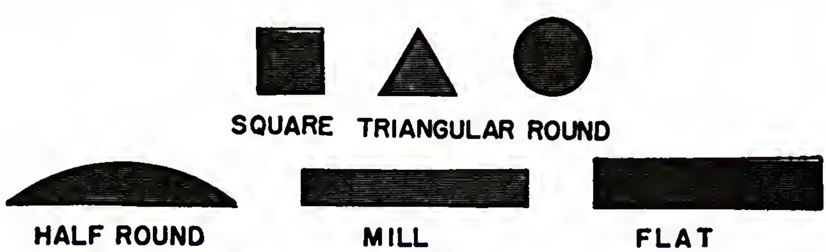


Figure 49.—Shapes of files.

and thickness. HAND files, not shown, are somewhat thicker than flat files. They taper slightly in thickness but their edges are parallel.

SQUARE files are tapered on all four sides and are used to enlarge rectangular-shaped holes and slots. ROUND files serve the same purpose for round openings. Small round files are often called "rat-tail" files.

The HALF-ROUND file is a general purpose tool. The rounded side is used for curved surfaces and the flat face on flat surfaces. When you file an inside curve, use a round or half-round whose curve most nearly matches the curve of the work.

WARDING files are extremely thin and have sharply tapered edges. Their chief use is on work where space is limited. KNIFE files have one thin edge and one thick edge, and are used on keyways, slots, etc. RASPS are usually used only on wood.

Kits of SMALL files, often called "Swiss Pattern" files, are used to fit parts of delicate mechanisms, and for filing work on instruments. One kit contains eight or more assorted sizes and shapes. Handle these small files carefully because they break easily.

CUTS AND GRADES OF FILES

Files have either SINGLE-CUT or DOUBLE-CUT teeth. The difference is apparent when you compare the files in figures 50 and 51.

Figure 50.—Single-cut mill file.

Single-cut files have rows of teeth cut parallel to each other. These teeth are set at an angle of about

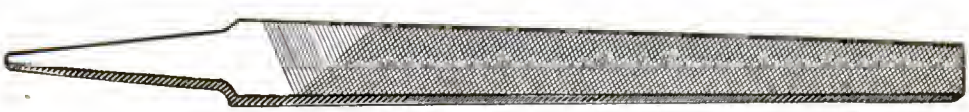


Figure 51.—Double-cut flat file.

65° with the centerline. You'll use single-cut files for sharpening tools, finish filing, and drawfiling (see figure 59). They're also the best tools for smoothing the edges of sheet metal.

Files with criss-crossed rows of teeth are double-cut files. One double-cut type is pictured in figure 51. The double cut forms teeth that are diamond-shaped and fast cutting. You'll use double-cut files for quick removal of metal, and for rough work.

Files are also graded according to the SPACING and SIZE of their teeth, or their COARSENESS and FINENESS. These grades are pictured in figure 52. In addition to the three grades shown, you may use some DEAD SMOOTH files, which have very fine teeth, and some

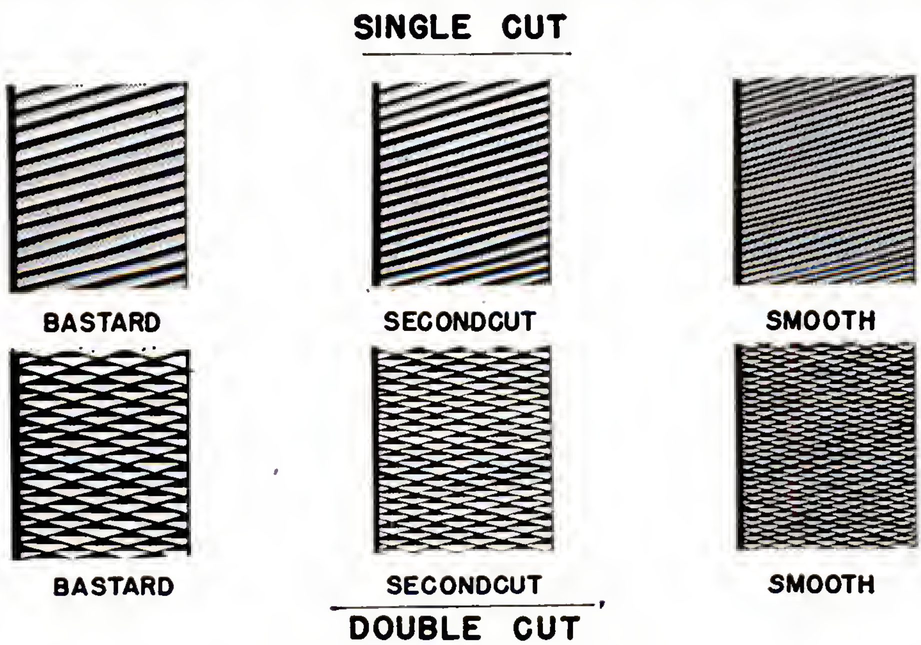


Figure 52.—Grades of file teeth.

ROUGH files with very coarse teeth. The fineness or coarseness of file teeth is also influenced by the LENGTH of the file. Compare the teeth of a 6-inch, single-cut smooth file and a 12-inch, single-cut smooth file and you'll notice the difference.

The flat or hand files most often used are the double-cut, second cut file for rough work and the single-cut, smooth file for finish work.

For smoothing soft metals such as aluminum and bearing metal, you may be supplied with a FLOAT-CUT file. It has large curved teeth and works with a plan-

ing action. It's fitted with the special holder pictured in figure 53, and it's also known as a vixen-cut file.

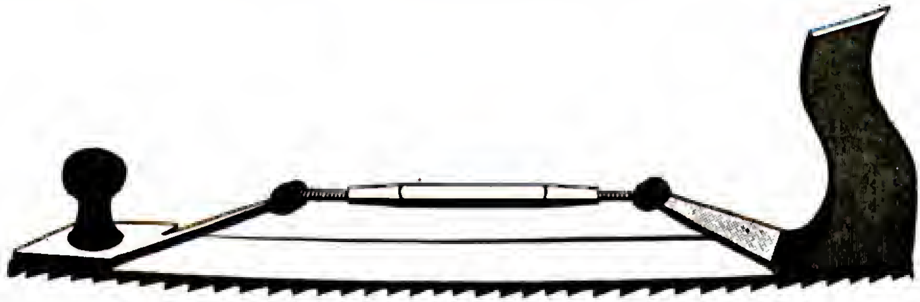


Figure 53.—Float-cut file.

USING THE FILE

Never use a file unless it's equipped with a tight-fitting handle. If you use a file without the handle and it bumps something or jams to a sudden stop the tang may be driven into your hand. To put a handle on a file tang, drill a hole in the handle, slightly smaller than the tang. Insert the tang end, and then tap the end of the handle on the bench top to seat it firmly. Make sure you get the handle on STRAIGHT.

The man in figure 54 is CROSS-FILING. Notice how he holds the file. The stroke is started with light pressure near the point of the file. As the file is pushed

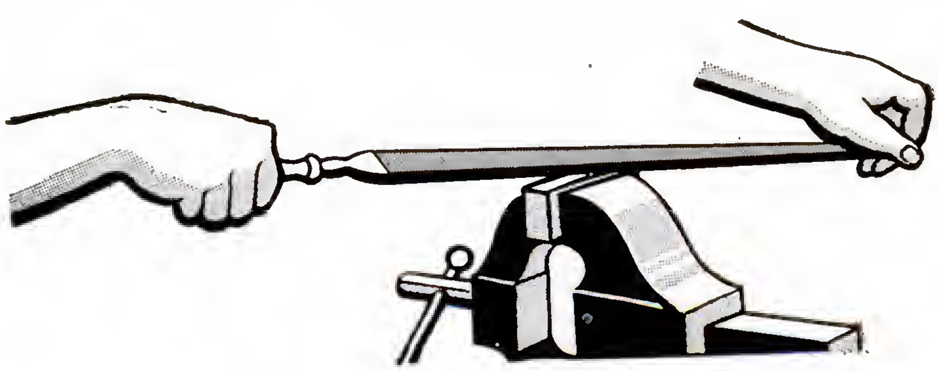


Figure 54.—Correct way to cross-file.

steadily across the metal stock he increases the pressure enough to make each tooth do its share of cutting.

He doesn't "force" the file, and he DOESN'T USE PRESSURE on the RETURN STROKE.

Avoid "hit and run" filing by making your strokes slow and steady. Too much speed causes the file to ROCK, and rounds off the corners of the stock as shown in figure 55*A*. Too much pressure BENDS the file, and has the same effect as pictured in figure 55*B*.

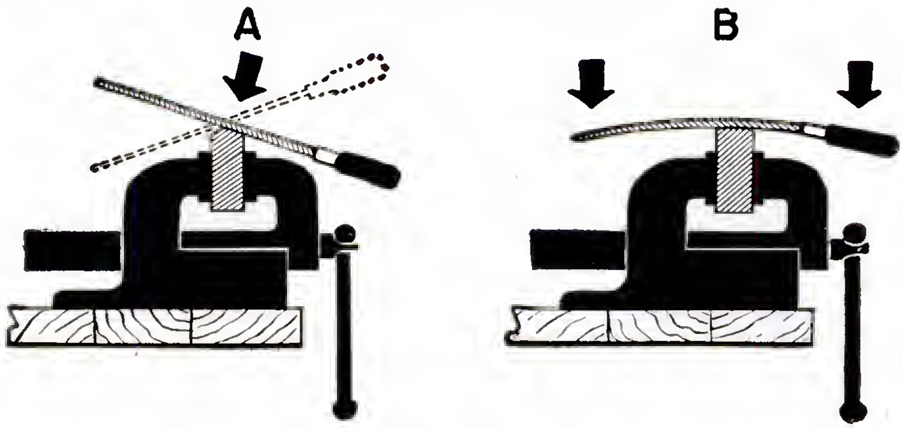


Figure 55.—Too much speed and too much pressure.

As you file, the teeth of the file will "clog-up" with some of the metal filings and scratch your work. This condition is known as PINNING. You can prevent it by keeping the file teeth CLEAN. Rubbing chalk between the teeth will help prevent pinning, but the best method is to clean the file frequently with a FILE CARD or brush. This card (figure 56) has fine wire bristles. Brush with a pulling motion, holding the card parallel to the rows of teeth—NOT up-and-down the length of the file.

If a few pins or chips are stubborn and won't come out, pick them out with a pick, or with a sharpened nail. DON'T USE YOUR SCRIBER—the chips may come out, but the scriber point will be ruined. Changing the lateral angle of the file with the stock will help prevent pinning. Clean the file and change the angle after every 10 or 15 strokes of the file, as pictured in figure 57.

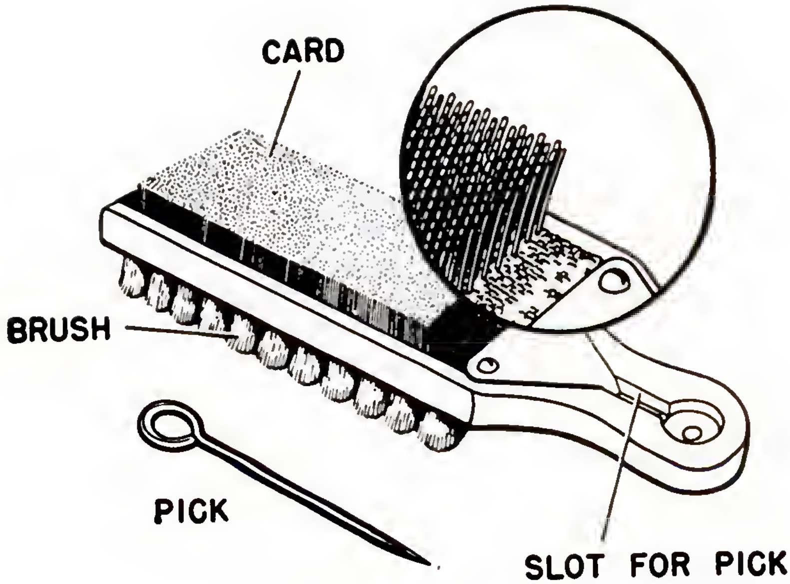


Figure 56.—File card.

File round objects with the swinging motion illustrated in figure 58. Work as close to the vise jaws as possible to prevent "chattering" (excessive vibration).

Surfaces and edges are often DRAW-FILED to make them smooth and true. In draw-filing, hold the file at right angles to the work, as shown in figure 59. Keep

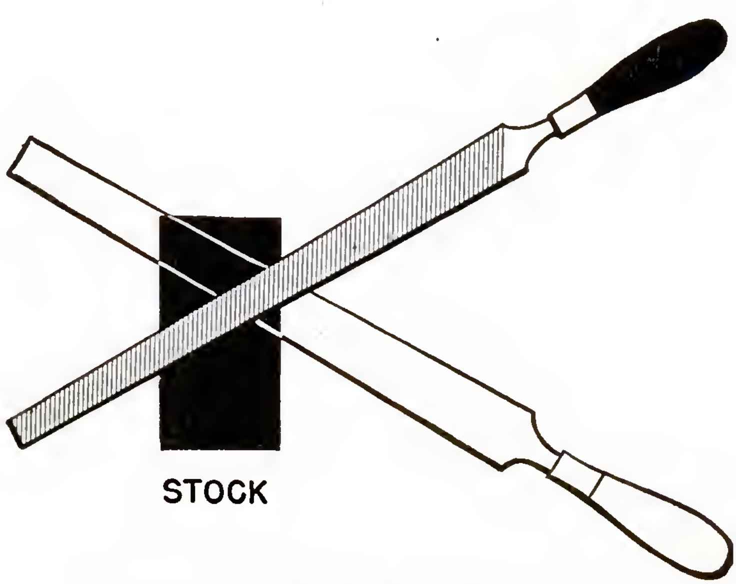


Figure 57.—Change the angle of the file.

PROTECT YOUR FILES

A new file should be broken in carefully by using it first on brass, bronze, or smooth cast iron. Just a few of the teeth will cut at first, so use a light pressure to prevent tooth breakage. And don't break in a file by using it on a narrow surface. The scale on hot-rolled steel and cast iron is so hard that it will ruin a good, new file. (Use old, worn files for removing such scale.) Protect the file teeth by hanging your files in a rack when they're not in use, or placing them in drawers with wooden partitions. Your files should not be allowed to rust—keep them away from water and moisture. For long file life, use the file card and brush frequently. Avoid getting files oily. Oil causes a file to slide across the work and prevents fast, clean cutting. Never use oil when filing cast iron—it causes the cast iron surface to "glaze over" and become hard and slick. You should wrap toolbox files in paper or cloth. This will save their teeth and prevent damage to other tools.

NEVER USE A FILE FOR PRYING OR POUNDING. The tang is soft and bends easily. The body is hard and extremely BRITTLE. Even a slight bend or a fall to the deck may cause a file to snap in two. Don't strike your file against the bench or vise to clean it—use your file card. And NEVER HAMMER ON A FILE—it may shatter and cause sharp chips to fly in all directions.

CHAPTER 5

CUTTING HOLES IN METAL

TWIST DRILLS

A man who uses tools must know how to drill holes in metal. The hand drill, breast drill, and brace are the common hand tools for holding and turning drills. You can easily drill holes in metal by hand if the holes are no larger than 1/4 inch in diameter. The actual cutting of such holes is done by a TWIST DRILL—an efficient tool that does its work by slicing metal away from the stock as it rotates. Twist drills are also used for cutting larger holes in metal—up to 4 inches in diameter—but for such purposes they are operated by power drilling equipment.

Twist drills are made of carbon steel or high-speed alloy steel. Carbon steel drills are satisfactory for the general run of work and you'll use them because they are inexpensive. When they get hot you can cool them in water. The more expensive high-speed drills are used for the tough jobs—drilling stainless steel, armor

plate, etc.—because they keep right on cutting when they are red-hot. Cool high-speed drills in still air. If you cool them quickly they may crack or split.

The SHANK of a drill is comparatively soft. It will bend easily, especially in the smaller sizes. The BODY of the drill is extremely hard and brittle. That's why drills chip and break easily when they're mistreated.

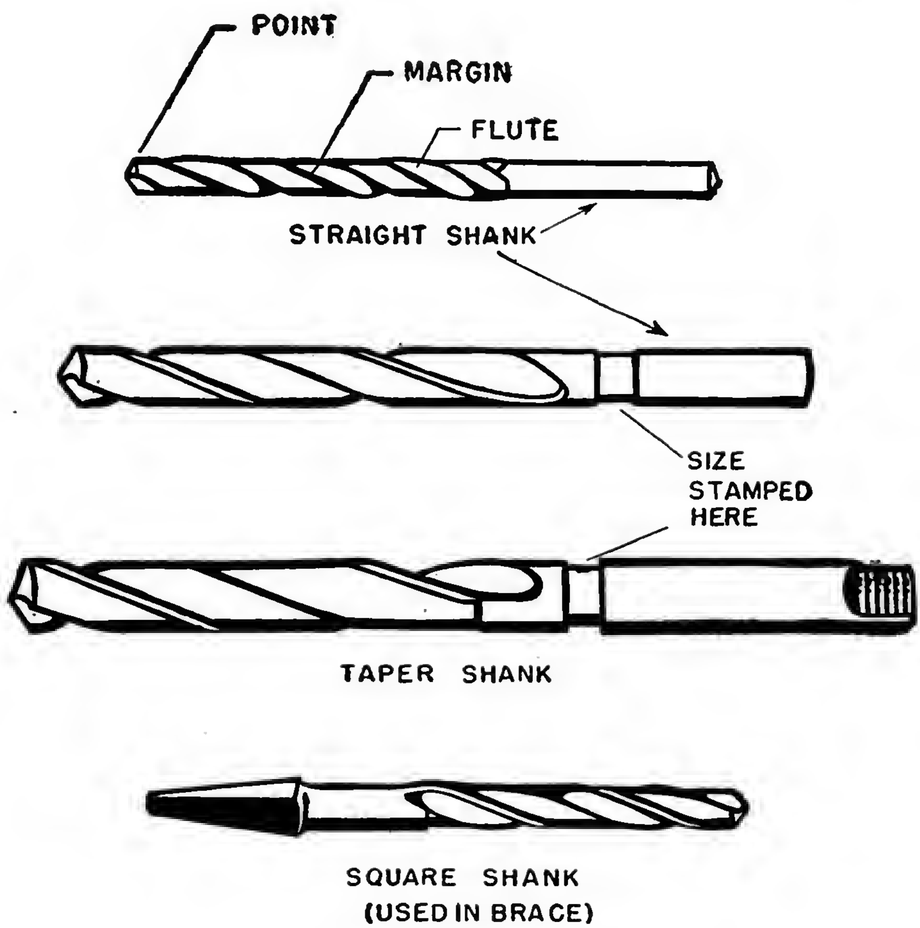


Figure 60.—Types of twist drills.

The STRAIGHT-SHANK twist drill will handle the average drilling job. It is the only type that fits the chucks of many hand drills, portable drills and most of the small drill presses, and is highly satisfactory for drilling holes up to ½ inch in diameter. Larger holes are usually drilled with the round, TAPERED-

SHANK, tang-type twist drills. The bit-stock drill is seldom used.

DRILL SIZES

The twist drills you'll use most frequently are those made in FRACTIONAL SIZES, $\frac{1}{64}$ inch up to 1 inch in diameter. You'll find the fractional size stamped on the shank of the drill. Because these drills vary $\frac{1}{64}$ inch (0.0156) from one size to the next, two other systems have been developed for special sizes—

NUMBER DRILLS—ranging from No. 80 (0.0135 inch) to No. 1 (0.228 inch).

LETTER DRILLS—ranging from A (0.234) to Z (0.413).

A table of these drill sizes is included in Appendix III of this book.

The METRIC SYSTEM is used by most foreign countries. In this system one inch is approximately equiva-

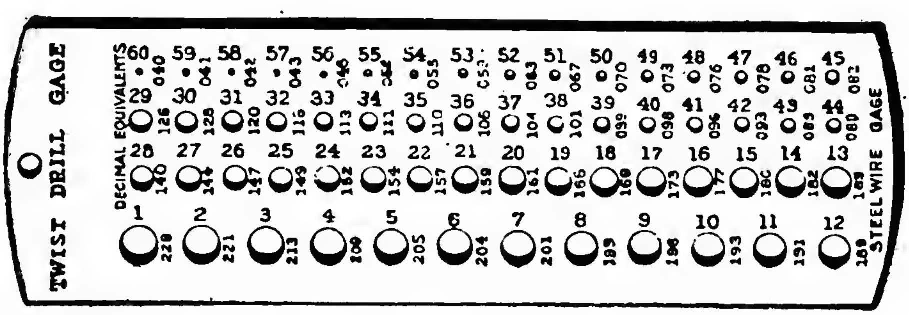


Figure 61.—Drill gage for number drills.

lent to 25.4 mm. (millimeters), and one mm. is about equal to 0.03937 inch. Metric drills usually vary in size by $\frac{1}{10}$ mm. (0.1 mm.).

If the size number has worn off the drill shank, you can check the size with a DRILL GAUGE for the number drills; with a DRILL STAND for fractional drills; or with an outside MICROMETER for ANY kind of drill.

When you measure with a micrometer, measure from the outside of one margin to the outside of the other margin, at the point of the drill. The shank diameter of a straight-shank drill is usually a few ten-thousandths of an inch smaller than the point diameter.

DRILLING BY HAND

You can drill holes $\frac{1}{4}$ inch in diameter, or under, by using a HAND DRILL. The hand drill, commonly referred to as an "egg-beater," is pictured in figure 62,

Figure 62.—Hand drill and breast drill.

alongside its big brother, the BREAST DRILL, which is designed to take care of tougher jobs. Crank the hand drill at a moderate speed, making sure that you hold it at the proper angle with the work, usually 90 degrees. Hold the drill steady, and maintain enough pressure to KEEP THE POINT CUTTING.

You may have trouble maintaining the proper angle at first, so make an extra effort to keep the bit at right angles to the stock you're drilling. You may want to

check the angle with a square now and then, at least until your eyes are trained to judge for themselves.

When your drill point is about ready to break through the metal, ease up on the pressure. If the drill jams or catches you can turn the chuck by hand to finish cutting the hole. Don't allow the drill to project through the hole any farther than is necessary to complete the hole. When the hole is completed, withdraw the drill IMMEDIATELY by pulling it back, as you continue to turn it in a clockwise direction.

PORTABLE POWER DRILLS

The PORTABLE ELECTRIC DRILL, figure 63, is used in the same way as a hand drill, except that you don't have to crank it. Power drills vary from ¼ HP to 1 HP and over. The chuck shaft, or arbor, is geared to the motor to obtain the desired speed.

Small drills are geared for high speed but the larger drills are geared down so the chuck will turn slowly enough to prevent damage to the drill from burning.

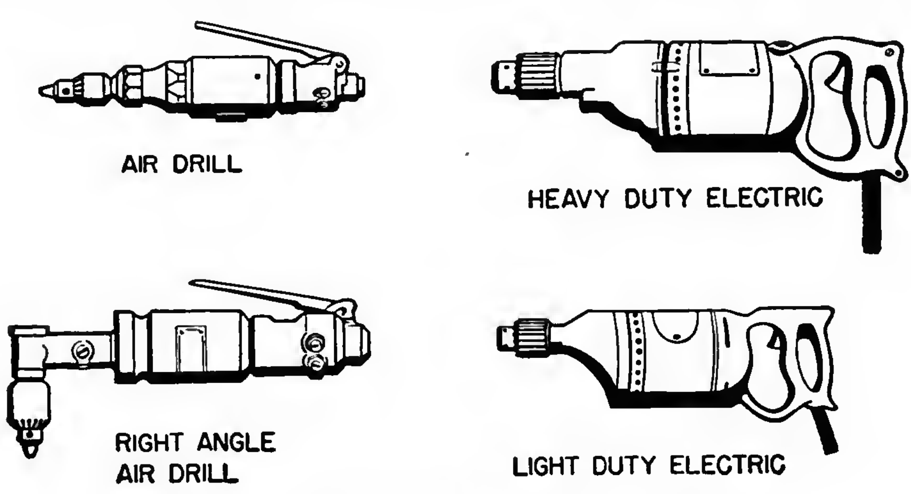


Figure 63.—Portable electric and air drills.

PORTABLE AIR DRILLS are rotated by compressed air. Speed and pressure may be controlled to fit the job. The air drills shown are especially useful for high-

speed drilling with small drills on light work. Heavy-duty air drills are usually used to drill holes of large diameter—½ inch to 4 inches.

You can also use portable power drills for such operations as buffing, polishing, and grinding. Special holders are used that are chucked in the same manner as a drill shank.

DRILL PRESS

The DRILL PRESS is arranged to hold and rotate the drill bit at the proper angle with the work. Drill press

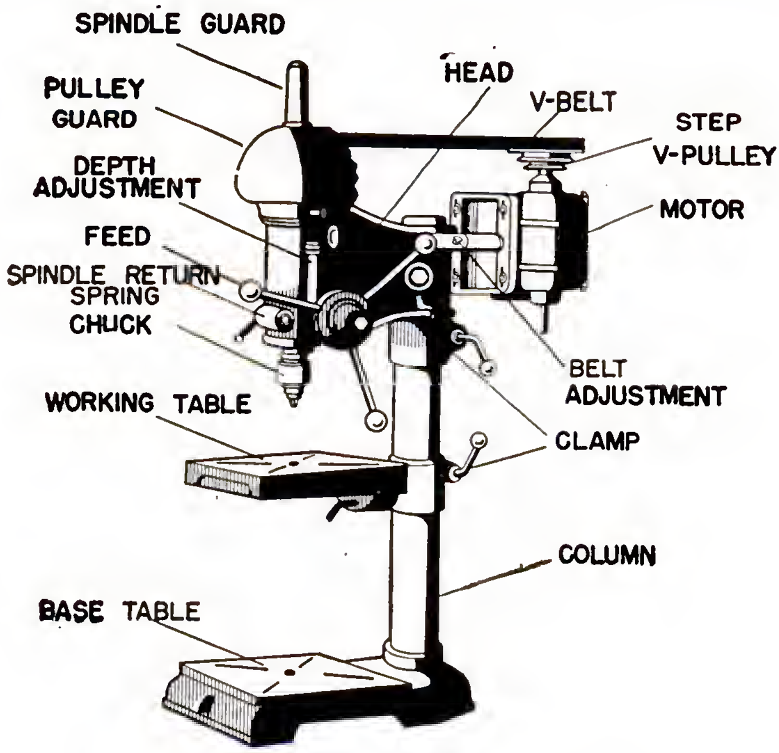


Figure 64.—One type of bench drill press.

sizes range from the small bench type seen in figure 64 to huge multiple-spindle jobs weighing many tons. You will probably have occasion to use the smaller drill presses only. These usually have a separate motor which drives the drill spindle and chuck by means of a V-belt.

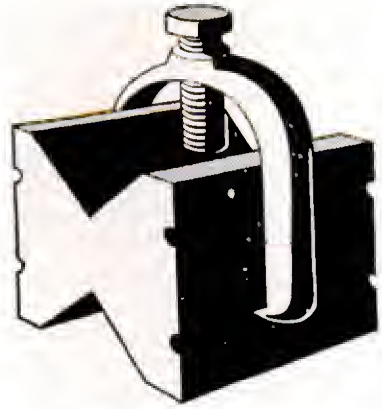
One advantage of the drill press over the portable electric drill is that you have SPEED CONTROL. Four grooves are usually found on the CONE STEP PULLEY of the motor and four on the spindle pulley. The drill press pictured in figure 64 has four speeds, and the belt is shown as adjusted for the highest possible speed. Notice that it's on the LARGEST-DIAMETER groove of the MOTOR pulley. This high speed—3,000 to 3,600 rpm—is suitable for small drills but is about 10 times too fast for a ½-inch drill. When you're in doubt, use the SLOWEST speed. That means changing the belt to the SMALLEST-DIAMETER groove of the motor pulley.

The feed pressure is easily controlled on the drill press by means of a feed wheel with long handles. A DEPTH STOP is provided to stop the progress of a drill at a predetermined depth. That's important when you're drilling blind holes—those that don't go all the way through.

SECURE THAT STOCK

When you use a drill press you can't afford to get your hands chopped up. But if you try to hold stock on the drill press table with your hands while drilling, you're asking for trouble. The drill may catch or jam and start the stock spinning like a buzz saw. If this happens the stock may fly loose and become a high-speed projectile, endangering all personnel within range. So remember whose side you're on. Hold that stock down with something besides your hands. You can hold it with pliers or a monkey wrench, but the best way is to use a DRILL VISE or a C-CLAMP. You may even have to design special holding jigs for some jobs. You can use a V-Block and clamp to hold round objects for drilling.

Use the DRILL VISE for small jobs. Clamp larger pieces of stock to the drill table. Before you turn on



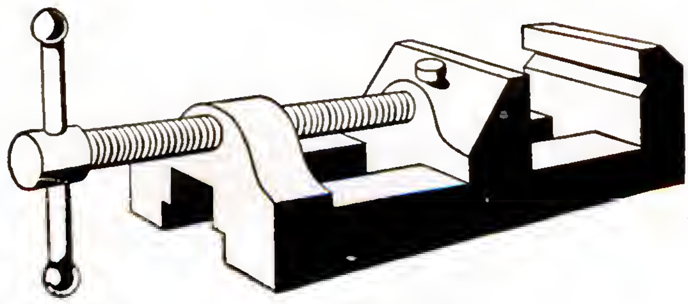


Figure 65.—Drill vise and V-block.

the power, revolve the drill a few turns by hand to make sure it is properly centered. And don't forget to drill PILOT HOLES before drilling large holes. You'll read about pilot holes farther along in this chapter.

CHUCKS

A CHUCK is the clamping device into which the twist drill is inserted. You'll find that most hand drills have three-jaw chucks that you tighten and loosen by hand. Power drills usually have gear-type, three-jaw chucks which are tightened and loosened by means of a CHUCK KEY, shown with the chuck in figure 66.

It's a serious shop crime to leave the chuck key in the chuck at any time. Always remove the key IMMEDIATELY after you use it. Otherwise the key will fly loose when the "juice" is turned on.

By now you may feel that the power drill is a lethal weapon. Actually, it's dangerous only when you fail to take the proper precautions. There's no danger if you just remember to—

CLAMP YOUR STOCK SECURELY.

USE THE CORRECT SPEED.

REMOVE THE CHUCK KEY.

DRILLING PRESSURE

Keep a drill cutting ALL the time it is in contact with the metal. Apply pressure steadily and uniformly to insure continuous cutting. The drill gets excessively hot if it is allowed to turn on the metal without cutting.

Did you ever slide down a rope and burn your hands? If you have, you know what frictional heat is. Twist drill temper is frequently ruined by overheating (caused by frictional heat). The point may even get hot enough to partially melt. You'll soon develop a pressure-control "feel," but until you do—take

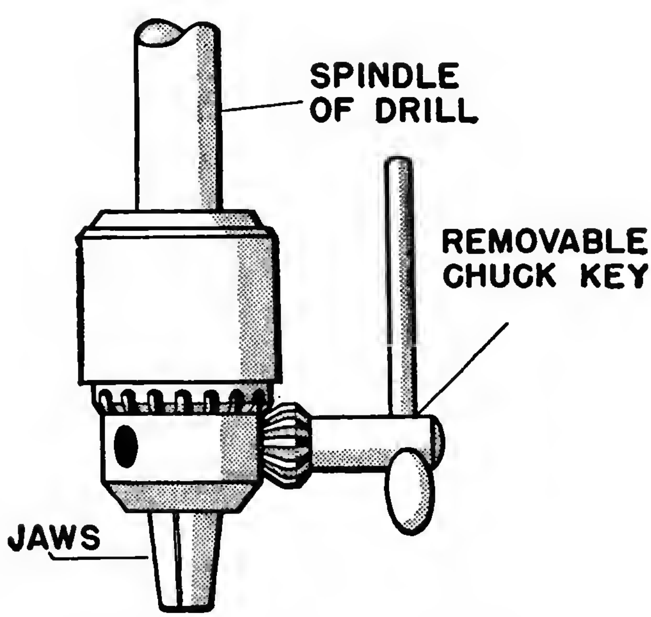


Figure 66.—Chuck and chuck key.

it easy and save the drill. Either too much or too little pressure is hard on the drill. It's the "happy medium" that pays off when you're using a drill.

PILOT HOLES

A small hole, used to guide and mark the path for a larger drill, is known as a PILOT HOLE. It's a good policy to drill these small guide holes for any drill size over 3/16-inch diameter. No special drills are required —just use 3/32- to 3/16-inch straight-shank twist drills. Select the pilot drill according to the size of the size of the finished hole you plan to make. A 1/8-inch drill is just right for pilot-drilling a 3/8-inch hole.

Here's why you need to drill pilot holes for large-size drilling work. In the first place it's difficult to start a large drill in a punch mark. The large drill has a tendency to DRIFT and "wander" from the center. Second, the center of a large drill has a thick WEB. The web or central area of a drill point is inefficient because of its construction. The thicker the web the more difficult it is for the drill to start cutting and keep cutting. Small drills have thin webs, so they cut more efficiently than large drills. The third "why" of pilot holes is that they guide, or pilot, the larger drill all the way through the metal and help to keep it "on the course."

REMOVING THE BURRS

You'll find that a drilled hole will have rough edges, or BURRS, around it on both surfaces. These must be removed. An easy way to remove them is to use a drill about twice the diameter of the hole. Hold the drill IN YOUR HAND, and rotate the point against the burrs to remove them. Some workmen prefer to secure the drill in a file handle for this sort of work.

Don't burr a hole too much. The hole should be a

true cylinder and not be countersunk or chamfered at either end unless that is SPECIFIED.

CHECKING THE DRILL POINT

The "business end" of a twist drill is known as the POINT. The point is formed by the ends of the web, flutes and margins of the drill body. The two sharp edges that do the cutting are called LIPS. The lips must be sharp and properly ground to be efficient.

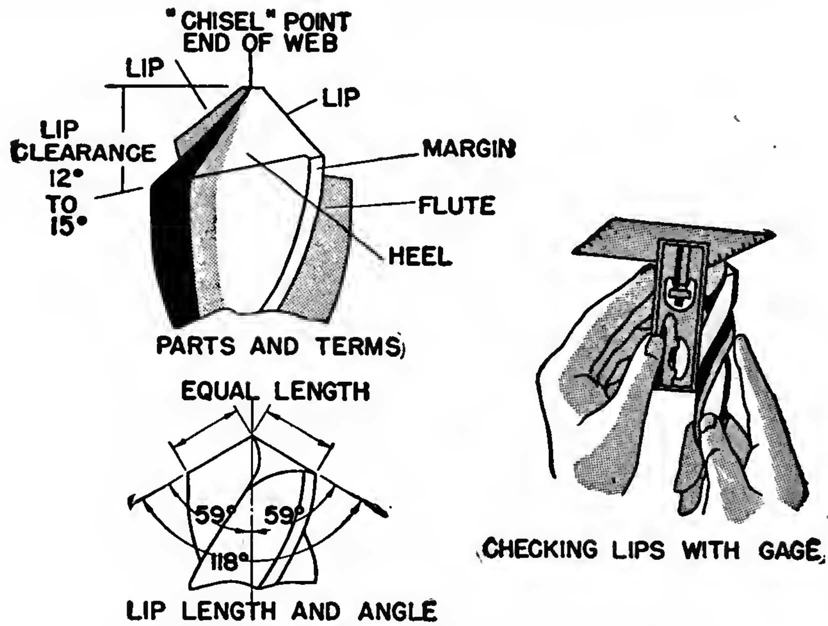


Figure 67.—Drill bit point; checking the lips.

It's surprising how many things can be wrong with a twist drill point. Get a twist drill—a ⅜-inch drill will do nicely—and check it carefully against this list—

LIP ANGLE—Do the two lips form the SAME ANGLE with the centerline of the drill? This angle should be 59 degrees.

LIP LENGTH—Both cutting edges (lips) must be the SAME LENGTH. A "lop-sided" point causes one lip to do most of the cutting, and this puts a terrific strain on the drill body. This strain is often great enough to crack and break the drill. Lips of unequal length also cause a drill to cut OVERSIZE.

LIP CLEARANCE—Only the two lips should contact the metal being drilled. The surface behind each lip must be ground back at an angle of 12 degrees —15 degrees to provide CLEARANCE for the lip. The results of too much clearance (and of no clearance) are pictured in figure 68.

LIP SHARPNESS—If the lips are rounded and dull, or chipped and burned, the drill won't cut properly.

FULL MARGIN—The margin-to-margin distance determines the diameter of the drill. If the margins are broken off or worn away, the drill will cut a tapered, undersize hole and will heat excessively.

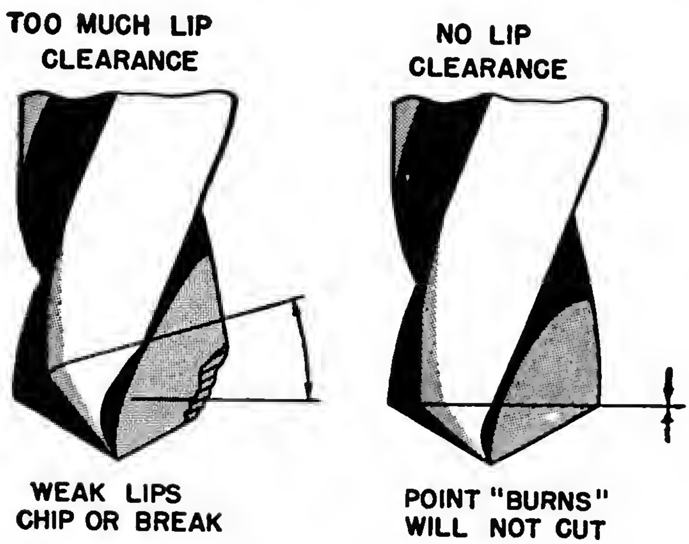


Figure 68.—Results of poor grinding.

Check the shank too—it's soft, and may be bent or burred. Burrs are easily removed with a smooth file. You can straighten the shank of a small drill by placing it on a steel plate and tapping down the high portion with a hammer. You can test for straightness by rolling the drill on a smooth surface.

GRINDING A TWIST DRILL

The best way to learn to shoot a rifle is by shooting one. A few good tips on point of aim, stance, trigger

squeeze, etc., help a lot, but just reading directions won't make you a sharpshooter. It's the same story when you learn to grind a drill. You can follow check points carefully, but you won't know how to grind a drill until you've had PLENTY of grinding PRACTICE.

To get started, select a 3/8-inch, straight-shank twist drill that HAS a properly ground point. Take this drill to the grinder and make a "dry-run"—that is, without

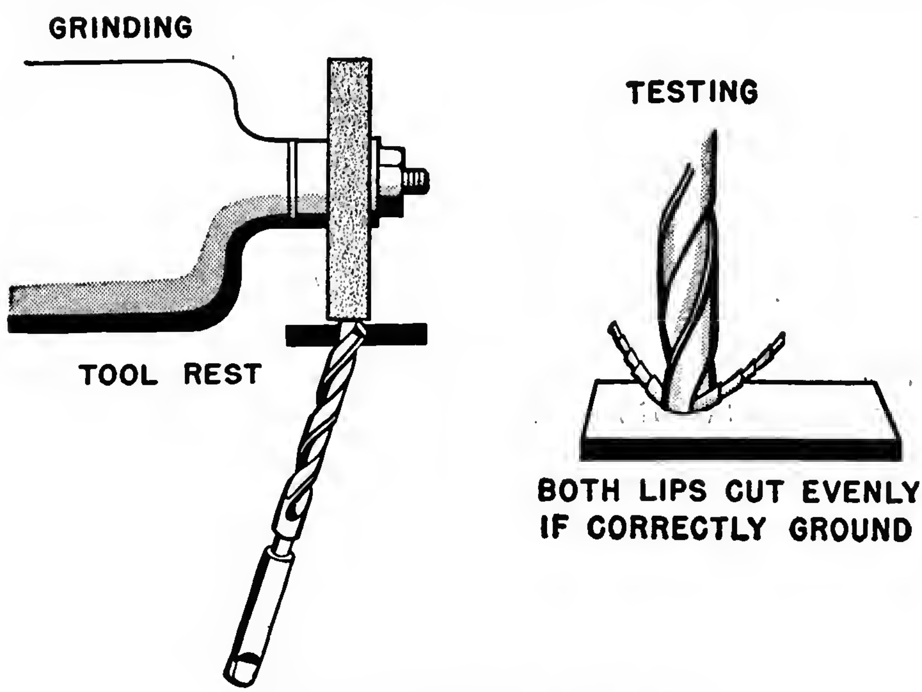


Figure 69.—Grinding the lips; testing.

turning on the grinder. Take a look at figure 69, and then follow these directions—

Hold the drill near the POINT with your LEFT forefinger and thumb. Cradle the drill in the first joint of your forefinger, and place the back of your finger on the tool rest. Grasp the drill SHANK with your RIGHT thumb and forefinger. Now keep the shank to the LEFT, and move the point forward so that one lip comes in contact with the grinding wheel.

Keep the shank slightly lower than the point. When the lip contacts the wheel, push down on the drill shank

so that the heel of the drill (back of the lip) is moved along the grinding wheel face. As soon as the back edge of the heel surface is reached the drill should be pulled away from the wheel.

Now flip on the switch and make a "live-run." Remove very little metal at first. Just polish up the point. Concentrate on maintaining the original shape of the point. You must move the drill steadily and evenly, and maintain uniform pressure against the wheel. Check your work frequently to make sure that you have the proper lip clearance (12 to 15 degrees), the proper lip angle (59°), and that the two lips are the same length. You can check the lips with a rule, and with gages.

Don't be discouraged if you have trouble on your first attempt. The average beginner has to grind three or four drills before he gets the hang of it and is able to do a satisfactory job.

As a final test, take the drill you have ground to the drill press and drill a hole in a piece of soft steel scrap. Does the drill cut smoothly and rapidly or does it jump and chatter? Are chips curling away evenly from BOTH lips? Is the hole the right size? A check with the drill shank will tell you. If the hole is oversize, the lips are either different in length or angle, or both.

And what if the drill you ground won't cut at all? Check the lip clearance. You probably don't have ANY.

Protect your drills from nicks and rust. Keep them in a rack or rolled in canvas holders. Make sure that each drill is properly ground before you put it away.

COUNTERSINKS

Countersinks are used to shape the ends of drilled holes to fit screw, bolt, and rivet heads of the countersunk type.

The three-lip, 82-degree type of countersink is usu-

ally used. Other point angles are available for special jobs and uses. The round shank of a countersink fits standard small drill chucks. Countersinks are made

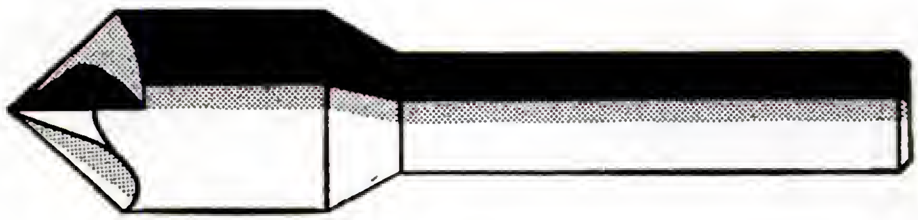


Figure 70.—82° countersink.

in a number of sizes, but any one size can be used on several different sizes of hole.

If a countersink is not readily available you can use a twist drill as a substitute. Select an old, stubby drill about twice the size of the hole for this purpose, and regrind the point to the required angle. The drill will feed and cut faster than a countersink, so be careful not to let it cut too deep.

COUNTERBORES

A counterbore, such as that shown in figure 71 is used to cut recesses in metal surfaces for fillister-head bolts and screws, and for similar purposes. The pilot

Figure 71.—Counterbore.

end of the counterbore is smooth, and is guided by the hole drilled for the bolt or screw. The counterbore works best when used in a drill press or lathe.

Reamers are used to smooth and enlarge holes to EXACT SIZE. Hand reamers, the kind you may use, have square-end shanks so you can turn them with a tap wrench or similar handle.

A hole that is to be reamed to exact size must be drilled about 0.003 to 0.007 inch undersize. A cut that removes more than 0.007 inch places an unnecessary strain on the reamer blades.

Reamers are made of either carbon tool steel or

SOLID STRAIGHT FLUTE

SOLID SPIRAL FLUTE

Figure 72.—Solid hand reamers.

high-speed steel. In general the cutting blades of a high-speed steel reamer lose their original keenness sooner than those of a carbon steel reamer. However, after the first super-keenness is gone reamers are still serviceable, and the high-speed tool will last much longer than the carbon steel type.

Reamer blades are hardened to such an extent that they are brittle, so handle reamers carefully to avoid chipping the blades. When you're reaming a hole, ROTATE THE REAMER IN THE CUTTING DIRECTION ONLY. Turn the reamer steadily and evenly to prevent "chattering" or marking and scoring of the hole walls.

Reamers of the types pictured in figure 72 are avail-

able in any standard size. The STRAIGHT FLUTE reamer is less expensive than the SPIRAL FLUTED reamer, but the spiral type has less tendency to chatter. Both types are tapered for a short distance back of the point to facilitate starting. These reamers are used where large numbers of similar holes are to be reamed. Bottoming reamers have no taper and are used to complete the reaming of blind holes.

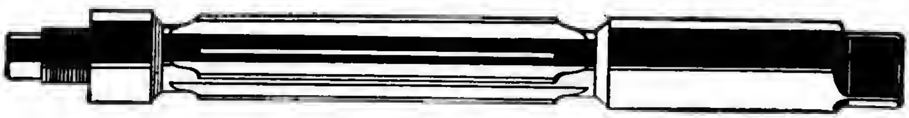


Figure 73.—Expansion reamer.

For general use, an EXPANSION REAMER, figure 73, is the most practical. This type is furnished in standard sizes from $\frac{1}{4}$ to 1 inch, increasing in diameter by 32nds. Each reamer has a maximum expansion of $\frac{1}{32}$ inch so a set covers any reaming job from $\frac{1}{4}$ inch to 1 inch.

Internal HONES are much like adjustable reamers. The principal difference is that hones have abrasive blades. Small hand hones are used for such jobs as fitting wrist pins in pistons. Large hones, rotated by electric drills or special motors, are used for such jobs as truing the cylinder walls of engine blocks.

TAPER reamers, both hand and machine operated, are used to smooth and true tapered holes and recesses. You may use them to ream out holes for tapered pins, such as those which secure pulleys and gears to shafts.

CHAPTER 6

THREADS AND THREAD CUTTING

USE OF THREADS

Threads are highly important in the construction of most mechanical devices. Your wrist watch, for example, has dozens of tiny threaded parts. If you ever had occasion to help overhaul an automobile or boat engine you will remember that you removed and replaced hundreds of threaded parts—bolts, nuts, studs, cap screws, shafts, rods, etc.

The principal use of threaded parts is to HOLD OTHER PARTS TOGETHER. But they are also used for MAKING ADJUSTMENTS, and they form OPERATING PARTS of some tools and machines. The micrometer is a good example of the last two uses—the anvil is threaded for easy adjustment, and the spindle is accurately threaded so that it will move a pre-determined distance with each revolution.

Threads are usually cut on the OUTSIDE of cylindrical objects or on the INSIDE of cylindrical holes. Inside threads are called INTERNAL THREADS; outside threads are known as EXTERNAL THREADS.

Threads for large threaded parts are usually cut on a machine lathe, but you won't have much opportunity to cut threads on a lathe unless you're a Machinist's Mate. You'll be cutting threads with HAND TAPS and DIES.

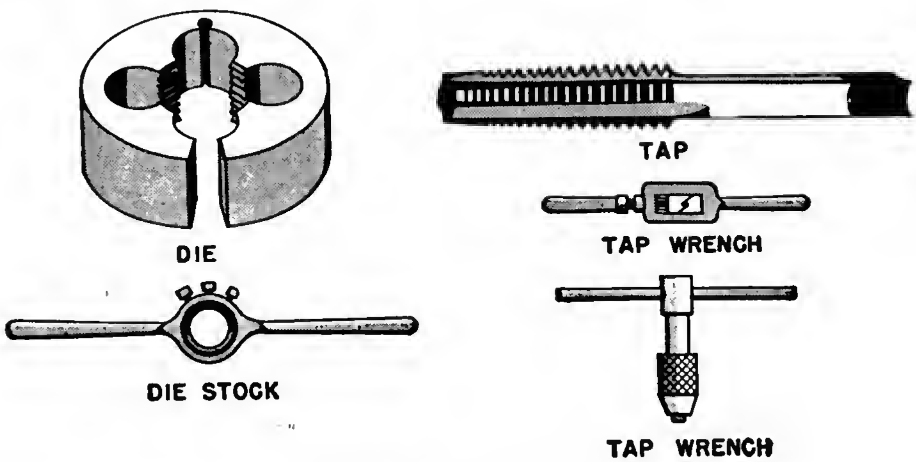


Figure 74.—Tap and die.

Glance at figure 74. Notice that the tap is used to cut internal threads. The process of cutting these threads is referred to as TAPPING. The cutting of external threads, done with a die, is known as THREADING. Use these terms when you talk about threads and thread-cutting so the other fellow will definitely understand what you're talking about.

All threads are not alike. They are designed, selected, and cut to FIT THE JOB. You'll find that threads vary in DIAMETER, PITCH, LEAD, FORM, and FIT.

THREAD DIAMETERS

The outside diameter of a thread is known as the MAJOR DIAMETER. The diameter across the ROOTS of the thread is called the MINOR DIAMETER. Look at fig-

ure 75 to make certain you have this correctly in mind.

Threads having a major diameter of less than 1/4 inch are called MACHINE SCREW THREADS. Their diameters range from 0.060 inch for size "0," to 0.216 inch

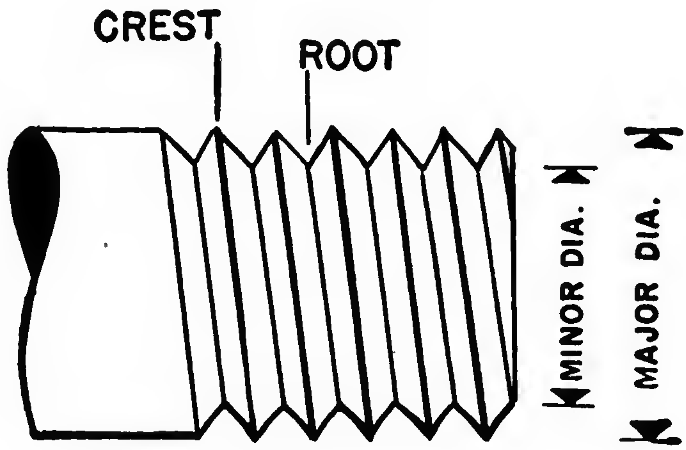


Figure 75.—Thread terminology.

for size 12. The diameters of these machine screws vary 0.013 inch from one size to the next. Sizes 7, 9, and 11 are not used. See Appendix IV for machine screw thread descriptions.

Threads having major diameters of 1/4 to 5/8 inch vary in diameter by 1/16 inch from one size to the next. From 5/8 to 1 1/4 inch thread diameters vary by 1/8 inch. Standard threads up to 1 1/4" diameter are described in Appendix IV.

PITCH AND LEAD

The PITCH of a thread is the measured distance from one thread crest to the next thread crest. The pitch of a thread is usually stated as the number of threads per inch, such as 8, 10, 12, etc. If a tap or die has "1/4—20 N.C." stamped on it, the "20" indicates the number of threads per inch, and the "1/4" indicates the major diameter of the thread.

You can determine the pitch of threads by measur-

ing across the thread crests with a rule, or by using a SCREW PITCH GAGE. This gage has a number of pivoted, knife-like blades whose edges are cut to represent the various thread pitches. Select and try the blades until you find one that fits the threads exactly, then read the pitch on that blade.

The LEAD (rhymes with "feed") of a thread is the

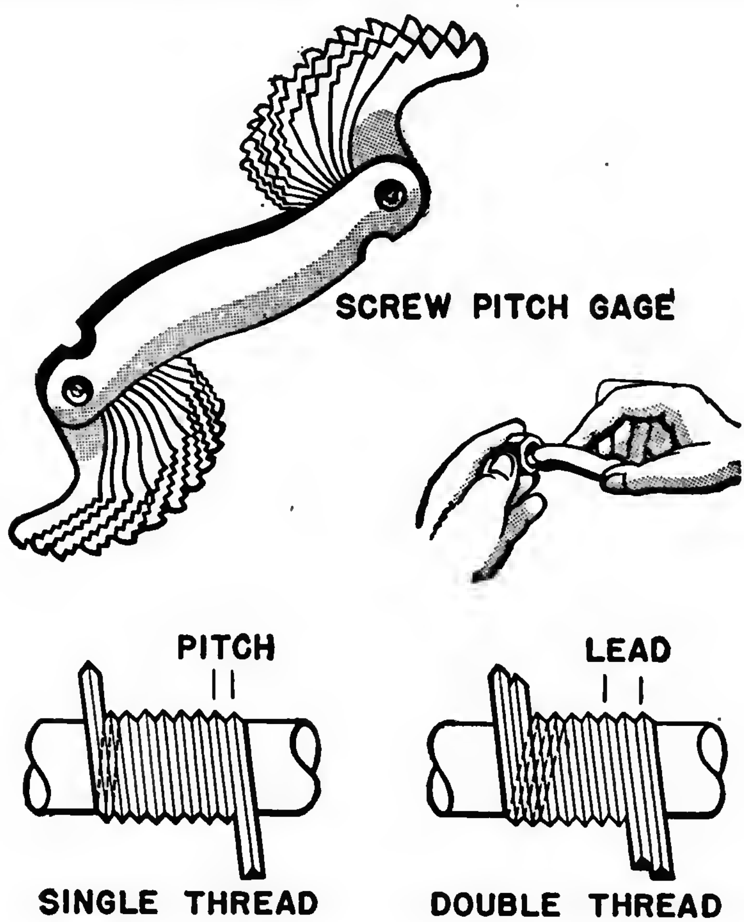


Figure 76.—Pitch and lead.

forward distance one point on a crest will move in one complete revolution of the threaded part. Most threads are SINGLE THREADS which have the SAME lead and pitch (L = P). For a double thread the lead is TWICE the pitch (L = 2P) and for a TRIPLE THREAD the lead is three times the pitch (L = 3P). This will all be clear if you study the diagrams in figure 76.

Double, triple, and quadruple threads are used where FAST TRAVEL of the threaded part is desirable. Hand taps and dies are made to cut only single threads. The others are cut on a lathe or a special thread-cutting machine. Single threads are usually used because they are easily cut, are stronger, and have less tendency to loosen than the multiple threads.

THREAD FORMS

The threads in figure 75 and 76 are of the V-TYPE, though the same rules for diameter, pitch and lead apply to all types of threads.

The SHARP V-THREAD is the type you normally think about when threads are mentioned. But this

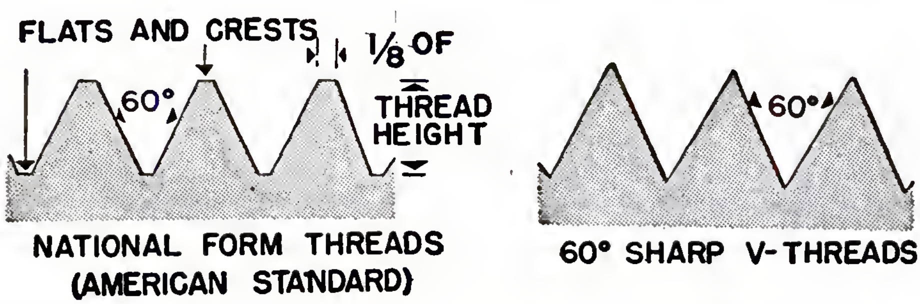


Figure 77.—Sharp V and National Form threads.

type of thread has serious disadvantages and is seldom used. Those SHARP CRESTS and ROOTS, shown in figure 77, are hard to cut accurately. The crests are easily dented and chipped, and the roots get fouled up with dirt and bits of metal.

The AMERICAN NATIONAL FORM THREAD, shown in figure 77, resembles the sharp V-thread, EXCEPT that the crests and roots are FLAT. The length of this flat portion, of both crest and root, is ⅛ of the pitch distance. Because of this design, National Form threads are not easily damaged and the roots are easily cleaned.

The National Form Threads are standardized into two series, National Coarse (N.C.) and National Fine (N.F.). The coarse thread series is used for rough work in heavy materials, while the fine thread series is usually used on small bolts, machine screws, adjusting mechanisms, etc.

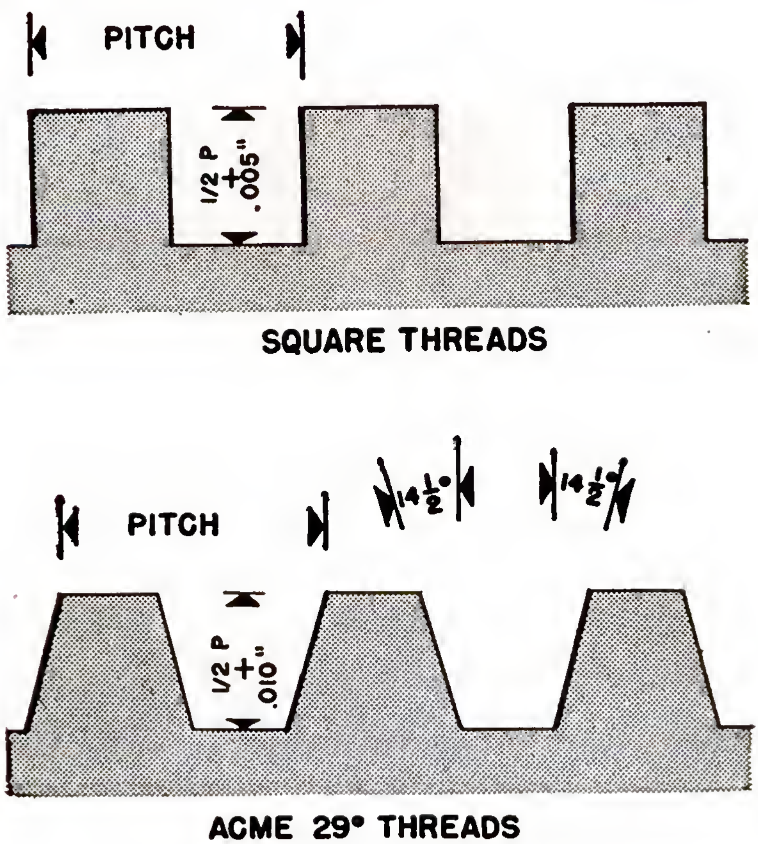


Figure 78.—Square and Acme threads.

See Appendix IV for tables of these thread series. The tables list size (major diameter), pitch, tap drill, etc. These are threads you'll use frequently, so remember where the tables are and refer to them.

Square threads, fig. 78, are strong and efficient. They are cut by machine. You'll see them in use as the tightening screw of vises, clamps, and jacks, and they are used on gun mounts, too.

Acme threads are heavy duty threads whose sides form an angle of 29 degrees with each other. These

threads can withstand heavy strains and loads, and are easier to machine than square threads.

LEFT-HAND THREADS are required by some machinery and installations. They advance COUNTERCLOCKWISE when turned. Left-hand threads are used infrequently and they're often marked so you won't turn them the wrong way. You can't use regular taps and dies (right-hand) to cut left-hand threads—you have to have special left-hand taps and dies.

THREAD FITS

When you go to small stores for a pair of dungarees you usually have two fits to choose from—too tight and too loose. Threads are tailored with four different fits—

No. 1.—Loose fit,
No. 2.—Free fit,
No. 3.—Medium fit,
No. 4.—Close fit.

The fit of threads depends on the clearance between the threads of mating parts. The No. 1 and No. 2 fits have considerable shake, or play, and are used on such items as stove bolts and bolts used for rough construction.

The No. 3 medium fit is the one specified for machine parts, engine bolts and most threaded parts. If a matching bolt and nut have very little play, and you can just turn them with your fingers, the threads probably have a No. 3 medium fit. If it's necessary to use a wrench, though without much pressure, you have a No. 4 close fit. This fit is used for the threaded parts of mechanisms that must be extremely accurate. If you fit a bolt with a nut that must be run on with a wrench, and considerable force must be used, it's a wrench fit (No. 5) not included above because it is seldom used.

Thread fits are often specified on blueprints, along

with the thread's major diameter, threads per inch, and thread series. Such a note will appear in this form,—¼—20 N.C.—3. The last number, "3" in this case, indicates the thread fit.

INTERNAL THREADS

When you cut internal threads by hand you'll use a tool called a TAP. A hole having internal threads is always known as a TAPPED HOLE.

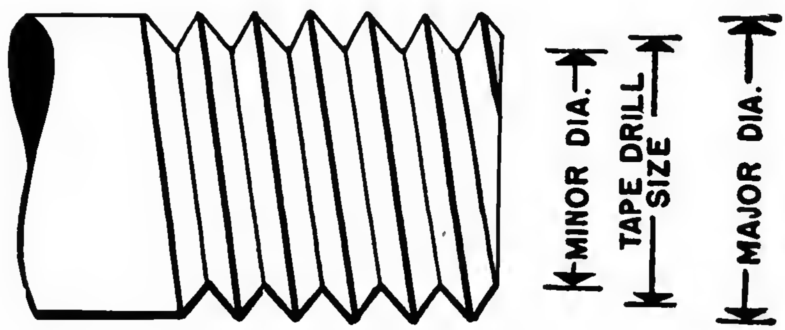


Figure 79.—Tap drill size.

Before you can tap a hole you must drill the hole, and the size to which you drill the hole is very important. This TAP hole must, of course, be smaller than the major diameter of the tap threads. Figure 79 shows the system used for figuring this. The resultant thread is known as a "75% thread" because the diameter of the hole is 75% of the DIFFERENCE between the major and minor diameters, subtracted from the major diameter.

Don't worry too much about this system. All you have to do to select the proper tap drill is to look in the tables of Appendix IV. N.F. threads require a LARGER tap drill than N.C. threads of the same major diameter, so be careful to pick the right one.

These tap drills ARE NOT special drills. They are STANDARD SIZES of fractional, number, or letter drills. If the specified size for your job isn't available, use the

next size larger, because if the tap hole is too small you may break the tap.

Hand taps are usually provided in sets of three taps for each diameter and thread series. Each set contains a TAPER TAP, a PLUG TAP, and a BOTTOMING TAP. The taps in a set are identical in diameter and cross-section. The only difference is the amount of taper, as shown in figure 80.

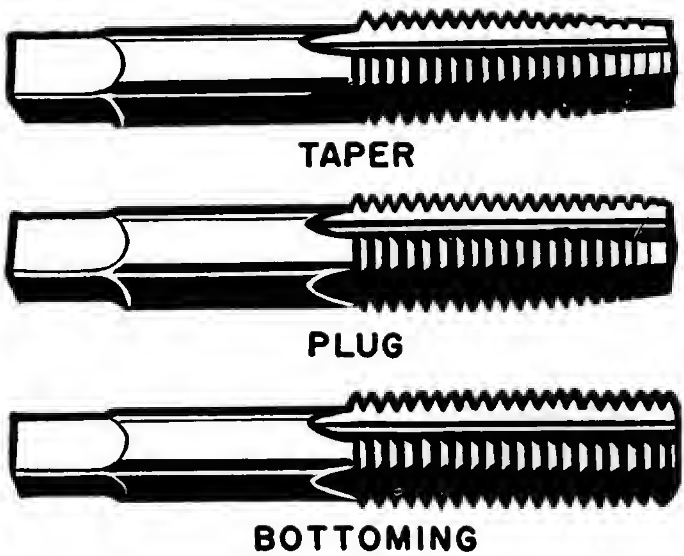


Figure 80.—A set of hand taps.

The taper tap is used to begin the tapping process, because it has a point that is tapered back for 6 to 7 threads. This tap cuts a COMPLETE THREAD when it's cutting above the taper. It's the only tap required when tapping holes that extend through thin sections.

The plug tap supplements the taper tap for tapping holes in thick stock. If the taper tap of a set is damaged or broken, you can use the plug tap as a starter, but take is easy—those taps are brittle and break easily. The taper of the plug taps extends back only 3 or 4 threads from the point.

The bottoming tap has NO taper. It is the tool to use if you have to cut full threads to the bottom of a blind hole.

USING THE TAP

Taps are held in TAP WRENCHES while they are being used. There are two types—the T-HANDLE for small taps and restricted spaces; and the ADJUSTABLE tap wrench for general use and for larger taps.

Here's how to tap a hole. Secure the stock in a vise, if possible. The best position is one in which the tap can be operated in a vertical position. Insert the taper

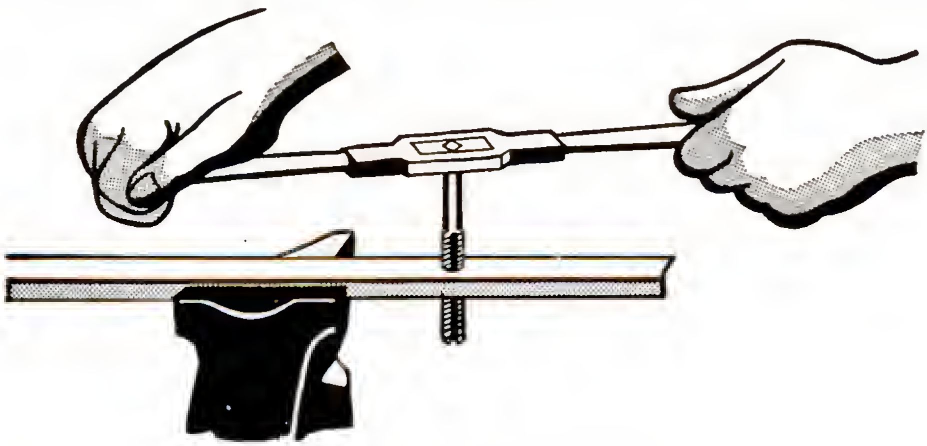


Figure 81.—Tapping a hole.

tap in the hole. Mount the tap wrench on the square shank of the tap, and start turning the tap in a clockwise direction. Apply enough downward pressure to make the tap start cutting. No downward pressure is necessary after the tap starts to cut.

DON'T TURN A TAP CONTINUOUSLY. Turn it forward about one-quarter turn, then back it up until you feel the chips break loose. Repeat this backing-up process for each one-quarter turn forward.

Taps, like drills, work better if you keep them cool. Use the same coolant you use for the tap drill. The coolant also helps the chips to flow out of the hole and from the flutes of the tap.

Taps are NOT strong. They snap off when you try to force them. The bottoming tap is a casualty more

often than the others. It's almost sure to break if you continue to try to turn it after the point has reached the bottom of the hole. It's good practice to stop a bottoming tap when the point is about $1/16$ inch (or one thread) from the bottom of the hole.

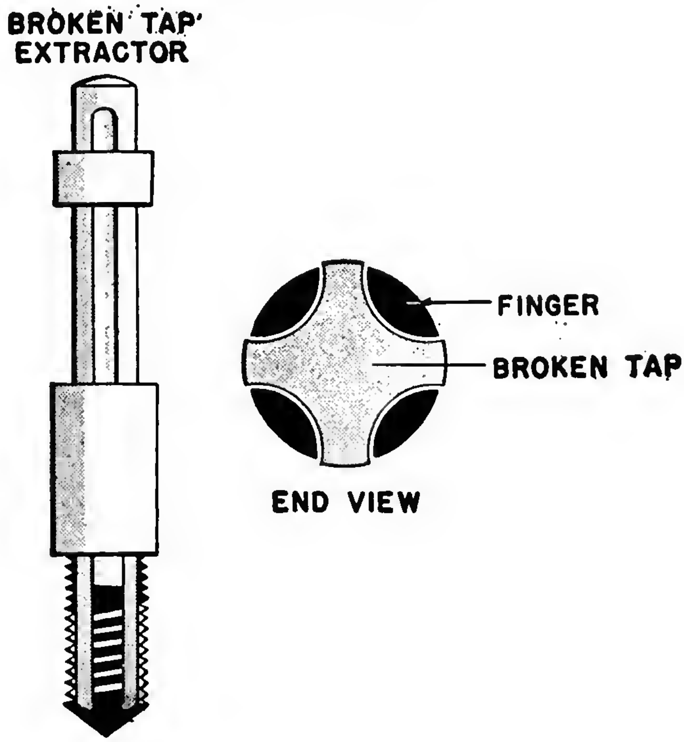


Figure 82.—Broken tap extractor.

If you are careless and break off a tap, it's up to you to remove the broken part—and that's not easy, brother. Try a TAP EXTRACTOR, like that in figure 82, if you have one. The type shown has four "fingers" that slip along the flutes of the tap. The tool is turned with a wrench, which must be used carefully to prevent damage to the long thin fingers of the extractor.

If an extractor is not available, you may be able to jar the broken part of the tap loose with a blunt cold chisel or a punch. If that method fails, try breaking up the tap into small sections. If all these methods fail, perhaps you can drive the broken tap out with a punch and tap the hole for a larger diameter thread. This procedure is definitely not regular, and won't be

permitted except in emergencies. And DON'T TRY TO DRILL OUT A BROKEN TAP—the tap is made of harder material than the drill.

The first time you break a tap, and then have to remove it, you'll decide that the best policy is to be CAREFUL.

EXTERNAL THREADS

When you cut EXTERNAL threads by hand you'll use some type of DIE, held in a DIE STOCK. Threads of large diameter and special shapes (squares and Acme) are cut on a lathe or special thread-cutting machines.

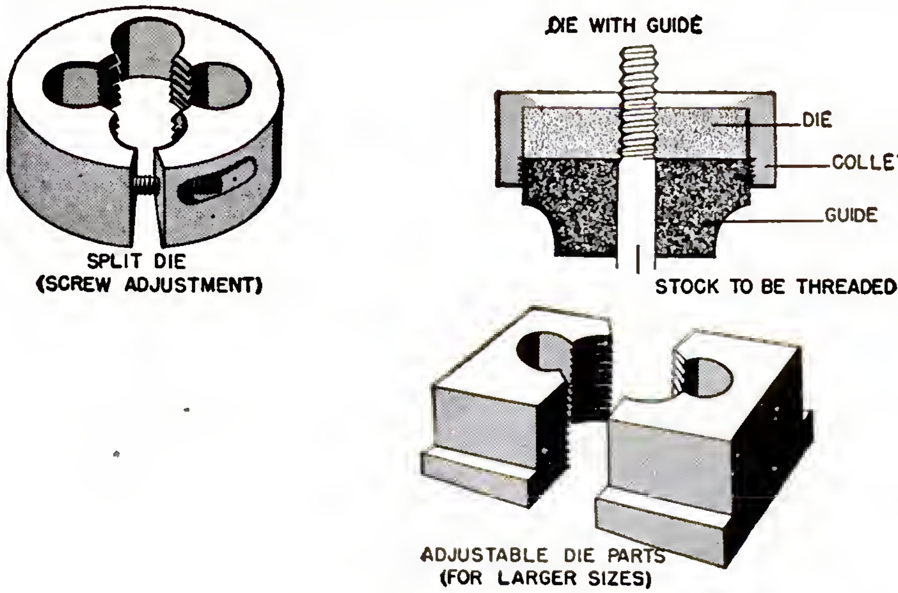


Figure 83.—Types of dies.

SPLIT, ROUND DIES are usually found in Navy tool kits. By adjusting the width of the split or slot, you can control the diameter and fit of the thread. Some of these dies are equipped with GUIDES, which help you to start the cut and keep the threads straight.

SOLID DIES are not adjustable, so you can't obtain any variety of thread fit when you use this type. Dies for larger diameters are made in two parts, which are removable, replaceable and adjustable. These two parts slide in a groove and are adjusted with a screw.

USING THE SPLIT DIE

The die won't start the cut readily unless you CHAMFER the end of the stock, as shown in figure 84*A*, to provide a starting place for the die. You can cut the chamfer with a file or on a grinder.

Die threads are tapered from one face only, so be sure to start the cut with that face. Reverse the die only when you're required to cut full threads up to a square shoulder.

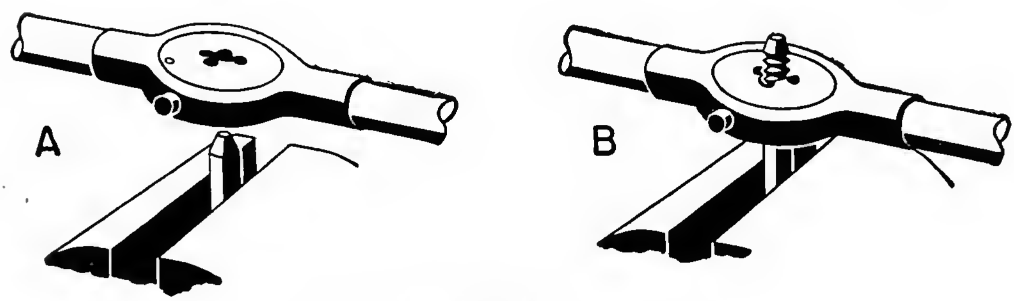


Figure 84.—Threading a rod.

Use the die as shown in figure 84*B*. Be careful to START the threads straight and to KEEP them straight. Back up the die occasionally to break loose the chips, and use a coolant to prevent overheating the cutting edges of the die.

Play safe by setting your die to cut oversize threads at first. You can always make the threads smaller, but you CAN'T make them any bigger. Remember that a TAP is NOT adjustable, so it's better to TAP FIRST, then cut the EXTERNAL threads on the mating piece to fit the tapped hole.

Examine finished threads carefully. You may produce crooked, inferior threads at first until you learn how to keep the die perpendicular to the rod. Each thread should be a FULL thread. A straight edge, when placed along the thread crests, should touch ALL the crests.

SCREW PLATES

SCREW PLATES are wood or metal boxes, containing from five to eight split dies with matching taps. Also included are a tap wrench, a die stock, one or two small screwdrivers for die adjustment, and the necessary tap drills.

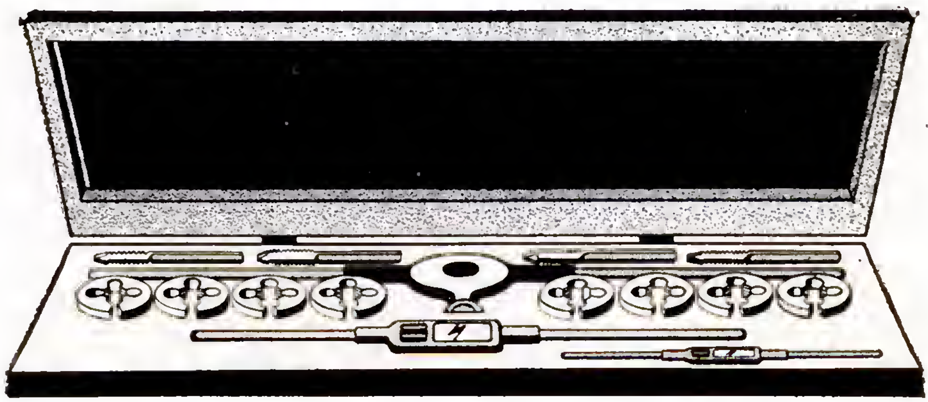


Figure 85.—A typical Navy screw plate.

Most Navy shops contain three or four of these kits for general purpose work. Additional taps and dies are provided in the sizes most commonly used.

Keep your taps and dies well oiled to prevent rust, and store them in such a way that the cutting edges won't be damaged.

PIPE THREADS

A ship's piping system carries liquids, steam and compressed air UNDER PRESSURE. Threaded pipe joints must be TIGHT. Pipe threads are TAPERED to provide a tightly-locked union. The STANDARD TAPER is ¾ inch per running foot of thread.

The standard pipe thread in the United States is the NATIONAL PIPE THREAD (N.P.T.). This thread is similar, except for the taper, to National Form N.C. threads.

Pipe threads are cut with special taps and dies. You'll learn about them in Chapter 8.

CHAPTER 7

METAL FASTENERS

KNOW YOUR STUFF

Metal fastening devices aren't exactly tools but you'll be using tools to install, remove, and adjust them, so learn all you can about them. Bolts, nuts, screws, rivets, and other fasteners should be known by their NAMES, USES, SIZES, and SHAPES.

Fastenings and fittings are used extensively aboard ship. They are usually kept in the storerooms or tool cribs of the various shops and are issued to you when you need them in your work. When you go to the storeroom or toolroom it's your responsibility to know WHAT YOU WANT so you can get it without any lost time or motion.

You are going to be maintaining and repairing mechanisms and installations that are held together with these fastenings, so you have to KNOW WHEN and WHERE they should be used, and HOW! Suppose you

used a FLAT POINT set screw where the job called for a CONE POINT? Plenty of trouble could result from such a simple mistake—an important installation might fail at exactly the wrong time.

DON'T SUBSTITUTE one type of fastening for another unless the change is AUTHORIZED. When you are allowed to use your own judgment, use the bolt, screw, or other fastening device that is best suited for that particular job.

MACHINE SCREWS

The term "machine screw" is the general term used to designate small screws used in tapped holes for the assembly of metal parts. Machine screws may be used

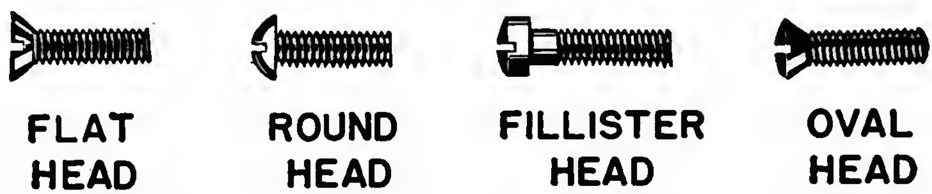


Figure 86.—Common types of machine screws.

with nuts, but usually they are screwed into holes that have been tapped with matching threads.

Most machine screws are made of steel or brass. They may be plated to help prevent corrosion. Special machine screws made of aluminum or stainless steel are obtainable for certain purposes, too. The latter are very strong and highly resistant to the corrosive action of salt water.

A great variety of diameters, lengths, and head shapes are manufactured. The complete description of a machine screw must include the LENGTH in inches, THREAD-DIAMETER, HEAD SHAPE, MATERIAL from which made, and FINISH. Here's a typical example—"½ inch, 8-32, round head, brass, chromium plated, machine screw." That "8-32" means that the screw gage is No. 8 and that it has 32 threads per inch.

Machine screws are driven with a screwdriver or wrench, depending on the type of screw head. Hex heads are turned with socket wrenches; slotted heads with plain screwdrivers; and Phillips heads with special Phillips screwdrivers.

Holes for FILLISTER-HEAD machine screws must be counterbored so that the head will be flush with or below the surface.

Most of the time you'll use the common types of machine screws shown in figure 86, but you may have

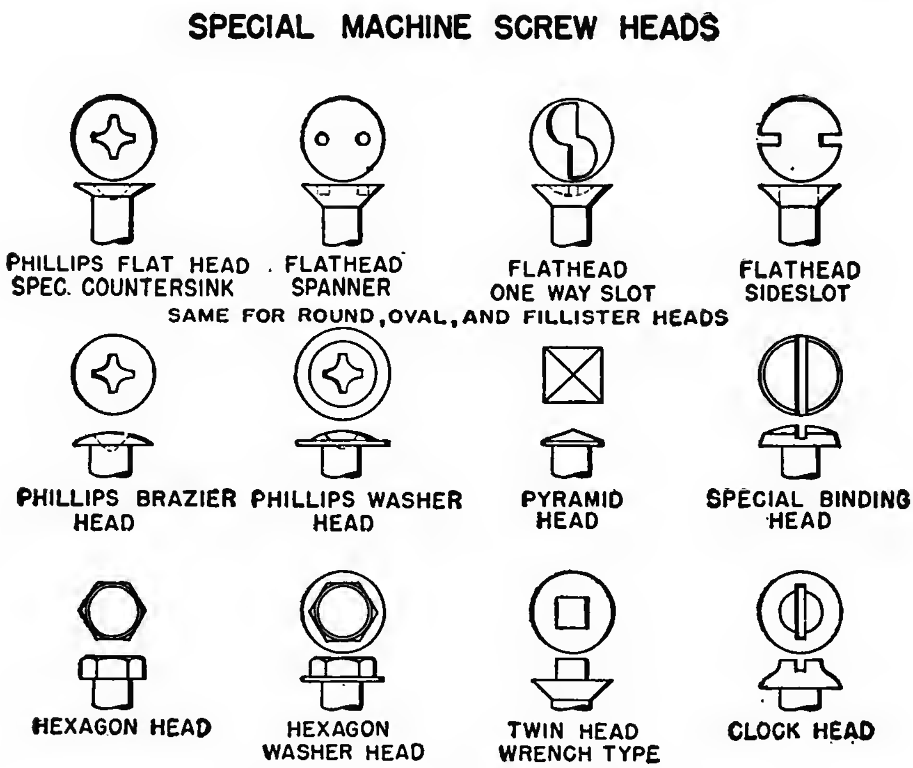


Figure 87.—Special machine screws.

occasion to use some of the SPECIAL types shown in figure 87. Note that some of these special machine screws require special tools for driving and removing. These tools are usually included in a kit that comes with the machine or installation on which the screws are used.

Nuts are seldom used on machine screws, but square or hex nuts may be. When a nut is needed, make sure the threads of the bolt and nut are the same gage and pitch. A table of machine screw gages and thread series is included in Appendix IV. You can use a screw pitch gage for checking the threads.

MACHINE BOLTS

MACHINE BOLTS are made in a variety of diameters, lengths, thread pitches, and head shapes. Standard threads are either N.F. or N.C., but most bolts have coarse threads. Bolts are furnished in three grades; machine finished, semi-finished, or rough. Diameters range from 3/16 to 3/4 inch, and lengths from 1/2 inch to 30 inches. Larger bolts are seldom carried in stock, but are made up to fit as required.

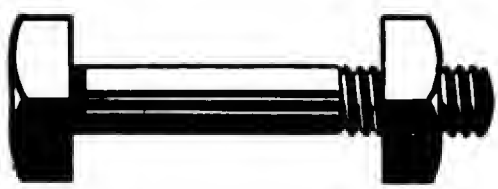


Figure 88.—Machine bolt.

Machine bolts are used to hold together the frames and structures of ships, buildings, and bridges, and for temporary structures that must be easily dismantled. Some bolts have holes drilled near the end of the threaded part for cotter keys or safety wire.

The nuts used on machine bolts may be either square or hexagonal, and bolt heads may also be of either type. Washers are usually used with these bolts.

STOVE BOLTS

Stove bolts are small, and were developed for use on stoves as the name suggests. But they can be used for plenty of other jobs where accuracy and strength are not required and where vibration won't shake the nuts

loose. Stove bolts have special coarse threads which make a loose or free fit with the threads of the square nuts used with them.

Figure 89.—Stove bolts.

Notice, in figure 89, that stove bolts may have round heads, flat heads, or "oven" heads, and either regular slots or Phillips slots. When you call for stove bolts at the toolroom you should specify the kind of head, body diameter and length you require.

CARRIAGE BOLTS

CARRIAGE BOLTS have "brazier" or "dunbar" shaped heads, and short square shanks just under their heads. This square portion prevents the bolt from turning. Their chief use is in wood structures, but they may be used with metal. Square nuts and flat washers are used on carriage bolts, and are supplied with them.

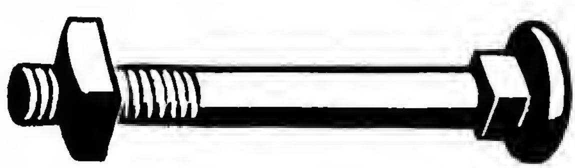


Figure 90.—Carriage bolt.

CAP SCREWS are usually used without nuts, to hold parts of machines and engines together. They are screwed into tapped holes, and are sometimes referred to as tap bolts. Threads may be either N.F. or N.C. Cap screws perform the same functions as machine screws but come in larger sizes for heavier work. Sizes range up to 1 inch in diameter and 6 inches in length.

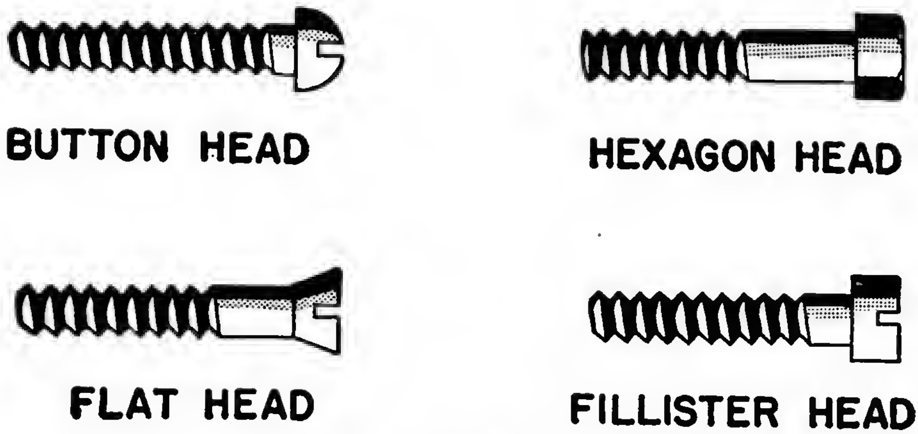


Figure 91.—Cap screws.

Cap screws may have square, hex, flat, button, or fillister heads. Fillister heads are best for use on moving parts because such heads are sunk into counterbored holes. Hex heads are usually used where the metal parts do not move.

The strongest cap screws are made of alloy steel, and can withstand great stresses, strains, and shearing forces. You may use some cap screws made of stainless steel. They are often specified on machinery exposed to salt water, which would soon corrode and "freeze" the threads of ordinary steel screws.

Some cap screws have small holes through their heads. A wire, called a SAFETY WIRE, is run through these holes to keep the cap screw from coming loose.

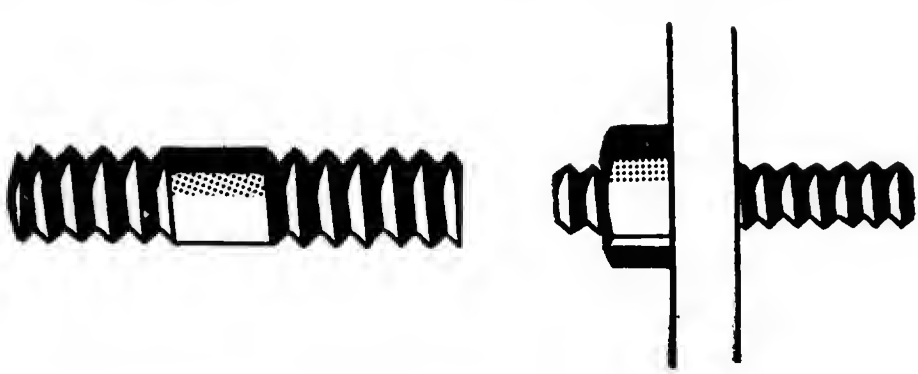


Figure 92.—Studs.

STUDS

STUDS might be called headless bolts. Both ends are threaded; one to screw into a tapped hole and the other to take a nut. You have seen them used to hold down the cylinder heads of boat and automobile engines. The use of a stud is really a safety precaution, because the nut may still be removed, even if the end screwed into the casting is "frozen." Because studs are usually used in castings they usually have coarse (N.C.) threads.

SET SCREWS

SET SCREWS are used to secure small pulleys, gears, and cams to shafts, and to provide positive adjustment

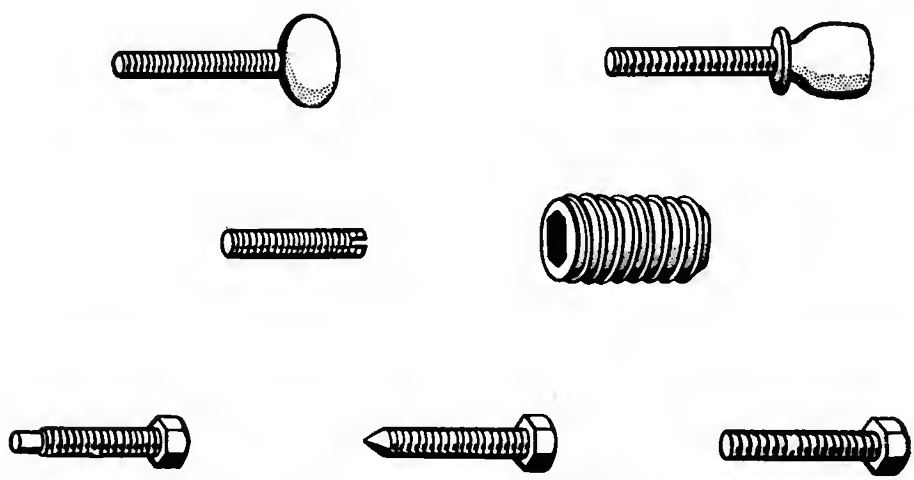


Figure 93.—Set screws and thumb screws.

of machine parts. They are classified by diameter, thread, head shape, and POINT SHAPE. The point shape is very important because it determines the holding qualities of the set screw.

Set screws hold best if they have either a CONE POINT or a DOG POINT, shown in figure 93. These points fit into matching recesses in the shaft against which they bear.

HEADLESS SET SCREWS—slotted Allen, or Bristo

types—are used with moving parts because they do not stick up above the surface. They are threaded all the way from point to head. COMMON SET SCREWS, used on fixed parts, have SQUARE HEADS. They have threads all the way from the point to the shoulder of the head.

THUMB SCREWS, figure 93, are used for set screws, adjusting screws, and clamping screws. Because of their design they can be loosened or tightened without the use of tools.

NUTS

SQUARE and HEXAGONAL nuts are standard, but they are supplemented by special nuts. One of these is the JAM NUT, used above a standard hex nut to lock it in position. It is about half as thick as the standard hex nut, and has a washer face.

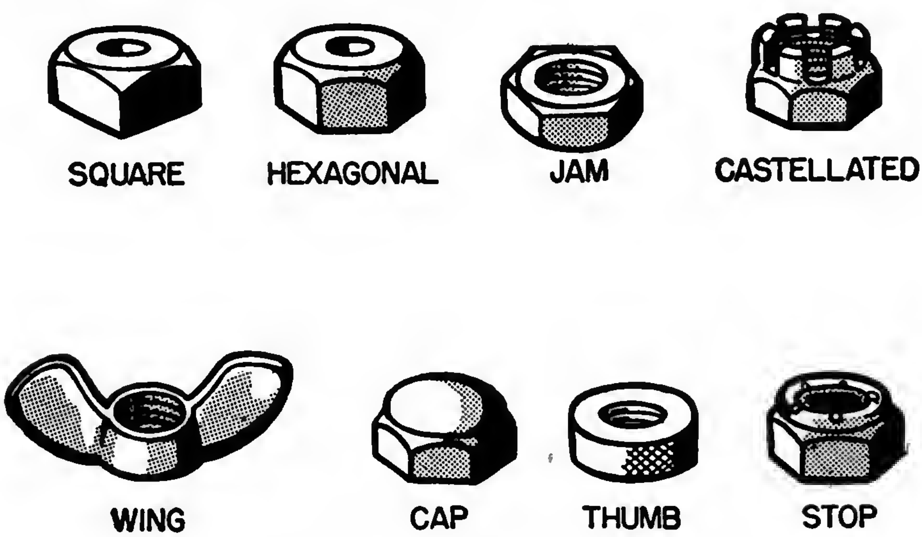


Figure 94.—Kinds of nuts.

CASTELLATED nuts are slotted so that a COTTER KEY may be pushed through the slots and a hole in the bolt. This provides a positive method of preventing the nut from working loose. You'll see these nuts used with the bolts that hold the two halves of an engine connecting rod together, for example. They are usually used with machine bolts.

WING NUTS are used where frequent adjustment is required. CAP, or ACORN nuts, are used where appearance is an important consideration. They are usually made of brass, which is then chromium plated. THUMB NUTS are knurled, so they can be turned by hand for easy assembly and disassembly.

ELASTIC STOP NUTS are used where it is imperative that the nut does not come loose. These nuts have a fibre or composition washer built into them which is compressed automatically against the screw threads to provide holding tension. You will find them used a lot (in the smaller sizes) for such installations as radio, sound equipment, and fire control equipment.

WASHERS

Common FLAT WASHERS are used to back up bolt heads and nuts, and to provide larger bearing surfaces. They also prevent damage to the surfaces of the metal parts through which a bolt passes.

Figure 95.—Washers.

SPLIT LOCK WASHERS are used under nuts to prevent loosening by vibration. The ends of one of these spring-hardened washers dig into both the nut and the work to prevent slippage.

SHAKEPROOF LOCK WASHERS have teeth or lugs that grip both the work and the nut. Several patented designs, shapes, and sizes are obtainable.

SPECIAL THREADED FASTENINGS

STRIPPER BOLTS, seen in figure 96, are used like cap screws, except that they have accurately ground and polished shoulders between the head and the threaded portion. This shoulder is used as a shaft for gears or cams, as a fulcrum for levers, etc. N.F. threads are standard on stripper bolts, and the heads may be hexagonal or fillister, with Allen or Bristo type slots.

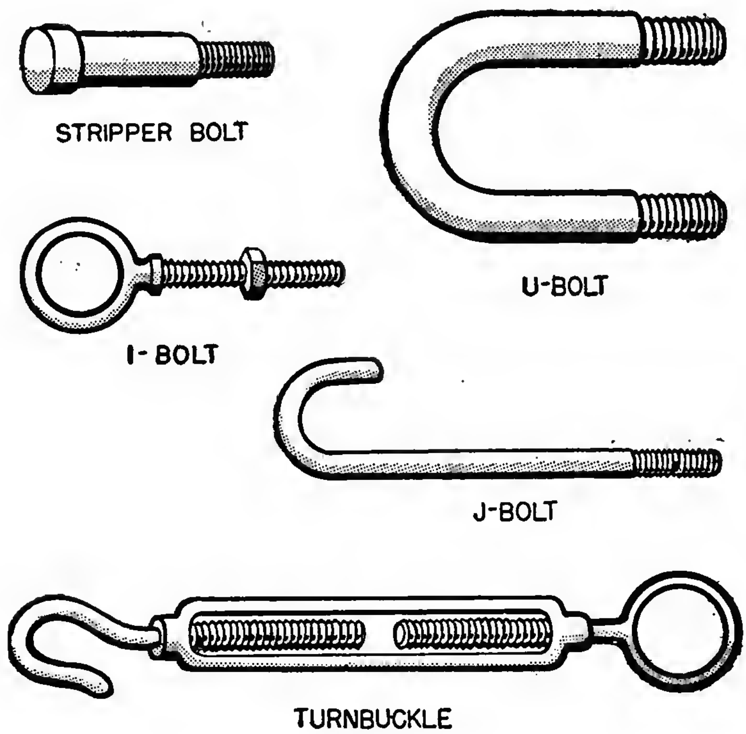


Figure 96.—Special fasteners.

You may have occasion to use EYE-BOLTS, J-BOLTS, and U-BOLTS. Their uses are obvious, as is the use of TURNBUCKLES. You will probably see other special threaded fastenings in use, because numerous types have been developed for use where regular fastening devices are not satisfactory.

SHEET METAL SCREWS

Sheet metal screws are used to hold sections of sheet metal, fiber, plastics, etc. They are universally known as Type *A* and Type *Z*. Type *A* has a sharp point and resembles a wood screw, except that the threads extend to the head of the Type *A* sheet metal screw. Type *Z* screws have blunt points and have finer threads than Type *A*. Type *Z* screws may be used with heavier sheets of material than Type *A* screws.

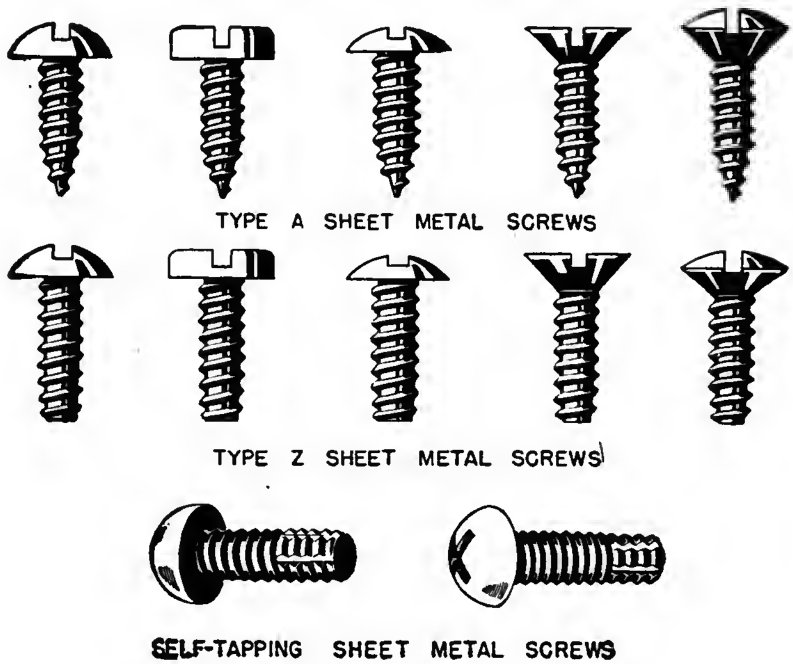


Figure 97.—Sheet metal screws.

Holes for these screws should be drilled or punched with about the same diameter as the core of the screw used. Figure 97 shows some of these screws. Note the variety of head shapes that are available. These screws are often called "self-tapping" screws, but this is INCORRECT. A true self-tapping screw is shown in figure 97. It has a tap end that actually CUTS THREADS.

KEYS AND PINS

COTTER KEYS are used to secure castellated nuts on

bolts and rods. They are also used as stops and holders on shafts and rods. SQUARE KEYS and WOODRUFF KEYS are used to hold hand wheels, gears, cams, and pulleys on shafts and arbors. These keys are strong enough to carry heavy loads if they are fitted and seated properly.

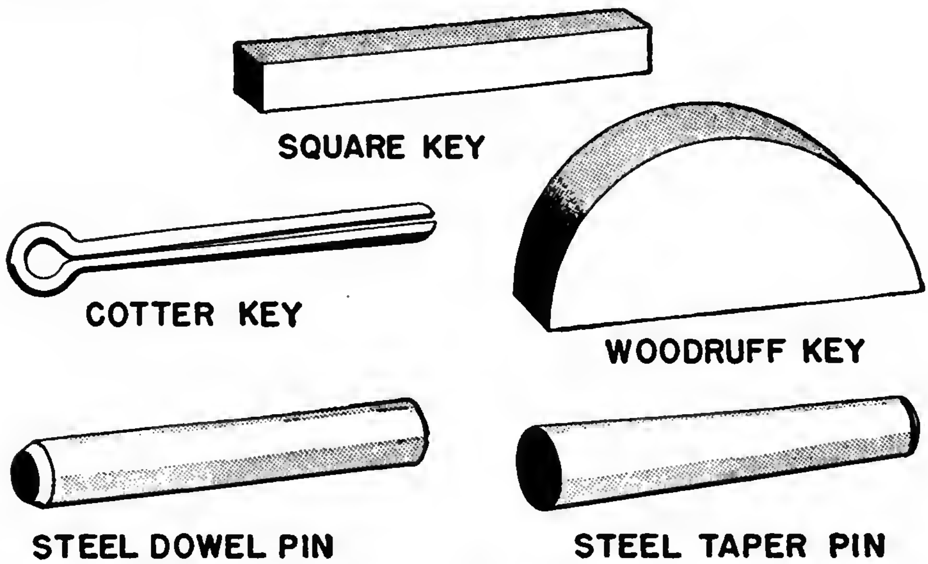


Figure 98.—Keys and pins.

TAPER PINS are used to locate and position matching parts. They are also used to secure small pulleys and gears to shafts. They usually have a taper of ¼ inch per foot. Holes for taper pins must be reamed with tapered reamers so they'll fit.

DOWEL PINS are used to position and aline the units or parts of an assembly. They are used in assemblies that must be frequently disassembled and assembled. One end of a dowel pin is chamfered, and it is usually .001 to .002 inch greater in diameter than the specified size. This allows the hole for the pin to be reamed to insure a close fit.

RIVETS

RIVETS are permanent fastenings and cannot be re-used. Holes for rivets are drilled or punched. They

must be carefully spaced and alined, and also have to be of the proper diameter and length, as determined by the thickness of the parts to be riveted.

TINNER'S RIVETS are used on thin sheet metal. They have flat heads, are made of soft iron or steel, and are usually coated with tin as a protection against corrosion. Sizes are determined by the weight of 1,000 rivets. Commonly used sizes are 10 ounce, 1 pound, and 2 pound. All rivets of one size are the same length. The length of a rivet is proportionate to its weight and diameter. They are usually sold in one-pound packages or boxes.

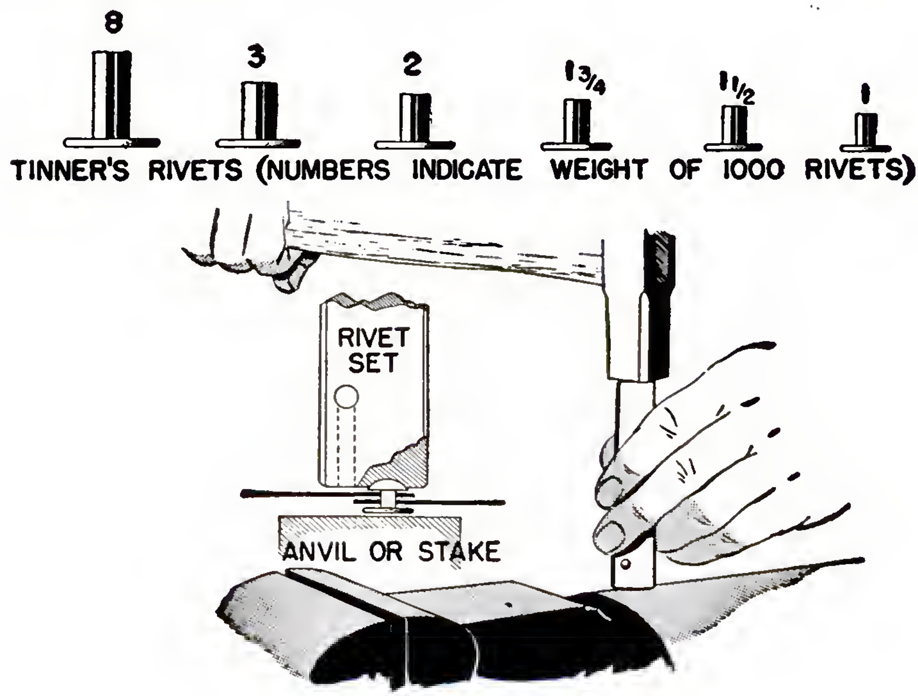


Figure 99.—Tinner's rivets; rivet set.

You will need to use a RIVET SET with tinner's rivets. The use of this tool is shown in figure 99. The set is used first to pull the rivet head tight against the sheets, and to press together the sheets to be riveted. After the rivet is upset (headed upon the headless end) with a riveting hammer, the set is used to round the upset end. Several sizes of sets are provided.

Small ROUND-HEAD RIVETS, made of iron, brass, aluminum, or copper, are used where appearance is the principal consideration. A rivet set of the proper size may be used on a round-head rivet to shape the upset head and improve its appearance.

STRUCTURAL RIVETS are used to fasten plates and structural members of a ship. They are used on all types of steel frameworks and structures, and are usually heated for driving so the rivets will contract when

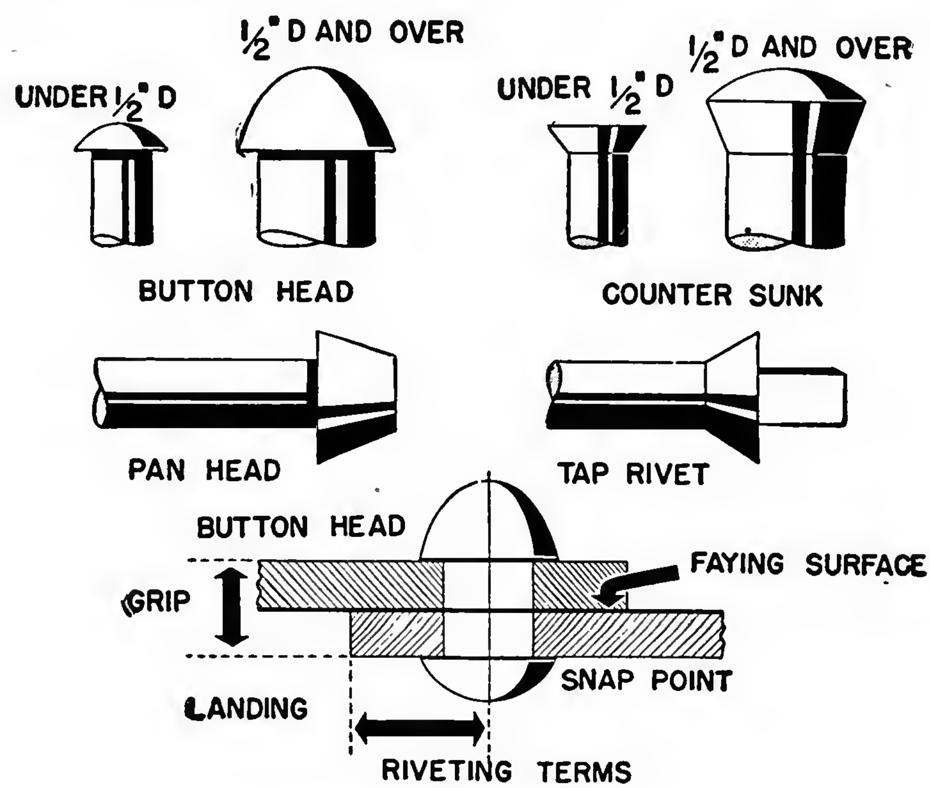


Figure 100.—Structural rivets.

they cool and hold the riveted members tightly together. The rivets also drive more easily when hot. Structural rivet diameters vary from $\frac{1}{4}$ to $1\frac{1}{4}$ inches, but even larger sizes are used for thick sections. The length of a rivet should be approximately one and one-half times the diameter of the rivet PLUS THE GRIP (combined thickness of the riveted sheets).

Note the terms used on the sectional view of figure 100. The center-to-edge distance should never be less than 1 $5/8$ diameters of the rivet. The space between rivets should be from 3 to 8 diameters of the rivet used, measured from center-to-center.

A rivet may be removed by cutting off the rivet head with a cold chisel and punching out the body of the rivet. A small rivet is easy to remove if the head is drilled before the chisel is used. The hole should be drilled through the head ONLY, and the weakened head cut off with a cold chisel.

CHAPTER 8

PIPE AND TUBING TOOLS

PIPING SYSTEMS

Pipes are used on board ship to move liquids and gases such as water, steam, fuel and compressed air. Tubes are used in much the same way as pipes, but have thinner walls and are usually of small diameter.

The materials used to make pipe and tubing are copper, brass, steel, cast iron, Monel, stainless steel, wrought iron, and lead. The type of fluid carried by a pipe is labeled on the pipe with a stencil.

The MAIN PIPING SYSTEMS for water, steam, drainage, etc., are made up of large pipes, which are joined either by BOLTED FLANGES or by WELDING.

Pipes up to two inches in diameter are usually joined with PIPE FITTINGS—unions, nipples, couplings, elbows, etc. These fittings are tapped and threaded with

standard pipe threads, which taper $\frac{3}{4}$ inch per foot of thread. The fittings are threaded during manufac-

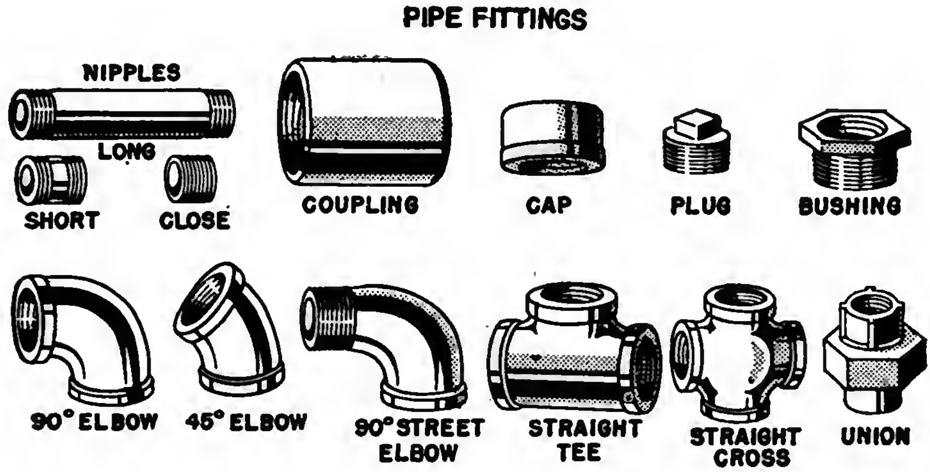


Figure 101.—Pipe fittings.

ture. Your job is to cut, bend, and thread PIPE, and to assemble pipes and fittings.

PIPE CUTTING

You can cut pipe with an ordinary hand hack saw, a power hack saw, or a PIPE CUTTER. You'll use the pipe cutter the most, but the power hack saw is faster if you have a large number of pieces to cut or if the pipe has a thick wall. The pipe cutter has a special alloy steel cutting wheel and two pressure rollers. These are adjusted and tightened by turning the handle. The whole tool is revolved around the pipe as shown in the lower illustration in figure 102.

The operation of the pipe cutter leaves a shoulder on the outside of the pipe and a burr on the inside. Always remove that inside burr or the ragged edges will catch dirt and other solid matter, and will block the flow. The BURRING REAMER, figure 102, is the tool you use to remove the burr.

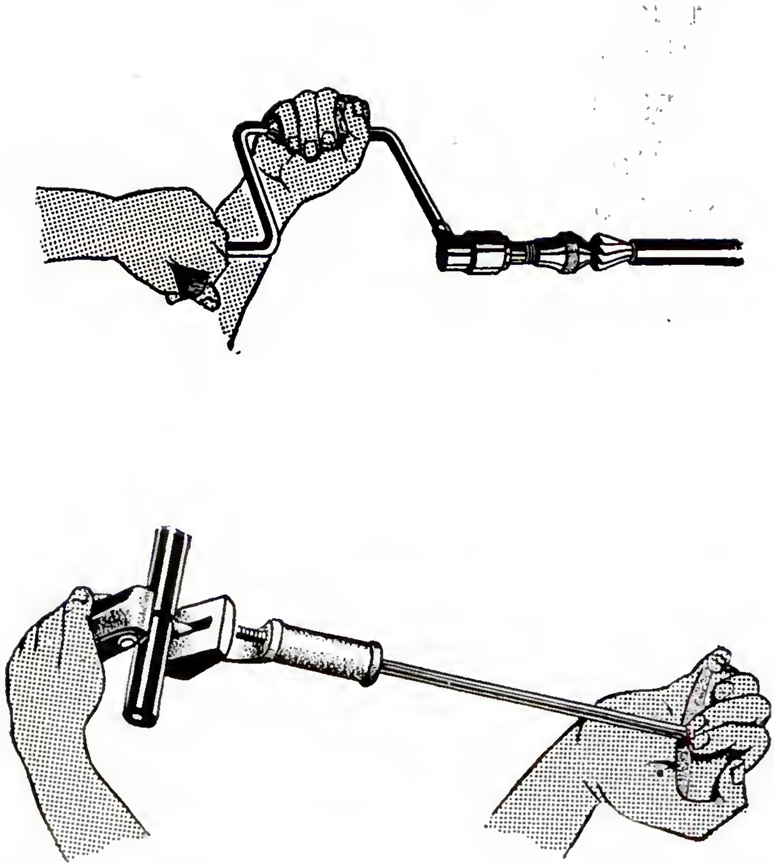


Figure 102.—Pipe cutter (bottom) and burring reamer.

THREADING

Adjustable and solid hand dies are used to cut standard pipe threads up to two inches in diameter. Some installations require LEFT-HAND THREADS, and you'll use LEFT-HAND DIES to cut them.

The threading procedure is about the same as that for the N.C. or N.F. threads. Machine oil or lard oil is used as a lubricant and coolant on iron and steel, but copper and brass are threaded dry.

A PIPE VISE, figure 103, is used to hold the pipe during the threading operation. The die, shown in the same figure, is adjustable and has a GUIDE CLAMP. This clamp fits over the pipe and is tightened with a thumbscrew. It draws the die on the pipe as the die stock is revolved. The clamp also helps you to get the threads straight.

When you use an adjustable die, cut only one half the depth of the thread at first. Then readjust the die to finish cutting the threads to the full depth.

The number of threads cut should not be greater than the number of threads of the die. The cut is complete when the end of the pipe is flush with the back

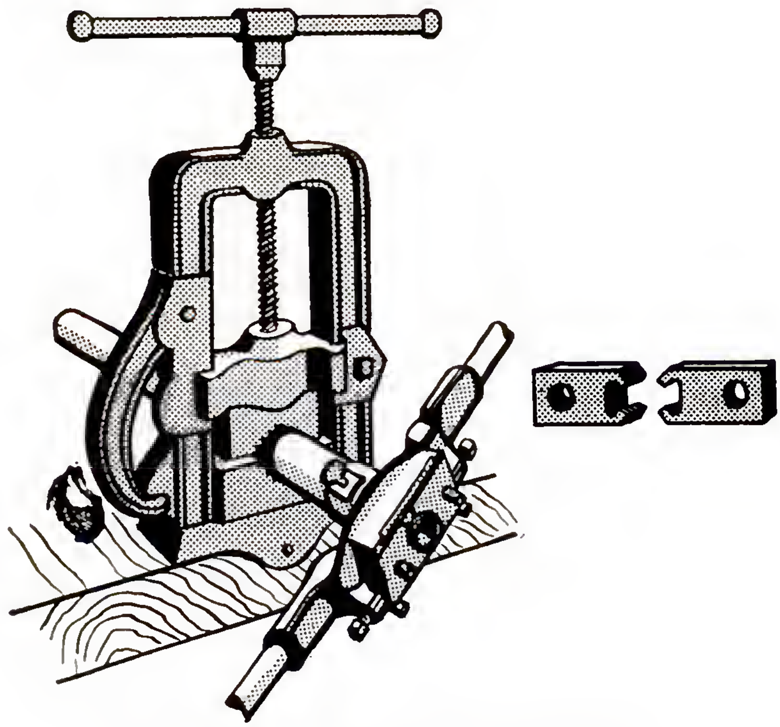


Figure 103.—Pipe vise, die, and die stock.

surface of the die. Don't forget to back up the die frequently to clear the chips.

When it's necessary to cut internal threads you'll use a PIPE TAP. It cuts standard pipe threads with $\frac{3}{4}$-inch taper per foot. Pipe taps are fluted and are like common screw taps, except for the taper. They are used with tap wrenches.

PIPE BENDING

Pipe bends, when they can be used, have advantages over fittings in that they offer no restriction to the

flow and are economical. The smaller sizes of iron pipe may be bent cold—IF the radius of the bend is not less than 10 times the diameter of the pipe. The seam of the pipe should be on the inside of the bend.

The bend of a pipe should be laid out on paper, on a layout table, or on the deck. If it's laid out on a metal surface, it's marked with soapstone. A wire template is made and used to check pipe bends.

Brass and copper pipe should be ANNEALED before it is formed or bent. Annealing softens the metal and increases its DUCTILITY—its ability to stretch, compress, and bend. You can anneal copper tubing by heating it to a cherry-red color and quenching it in cold water. Don't quench steel, aluminum, or brass tubing. Just let it cool in the open air.

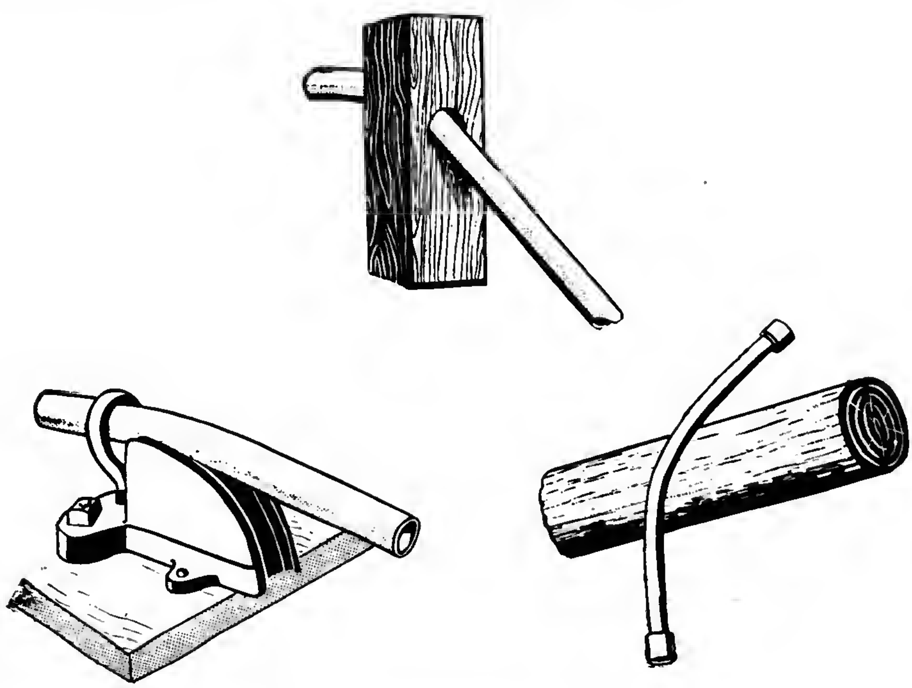


Figure 104.—Pipe bending.

The bending jig shown in figure 104 is a good tool to use in forming a pipe bend, or you can use one of the other methods shown. Avoid decreasing the inside diameter of the pipe by using as large a radius as possible for the bend.

Test all pipes that have been bent. There is some danger of leakage, due to seam splitting or through cracks caused by stretching.

If the pipe is large, and a short-radius bend is necessary, the pipe should be filled with dry sand, packed tightly, and plugged at both ends. Drill a small hole in one plug to allow the expanded air to escape. The pipe is heated to a bright red and bent to the shape desired. The tightly packed sand prevents the pipe from collapsing (caving in). If you are required to do much bending of heavy pipe you'll be provided with special bending equipment — tables, bending pins, clamps, winches and portable gas-heating units.

PIPE ASSEMBLY

Threaded water pipe joints are usually made up with red lead as a seal. Steam pipe threads are

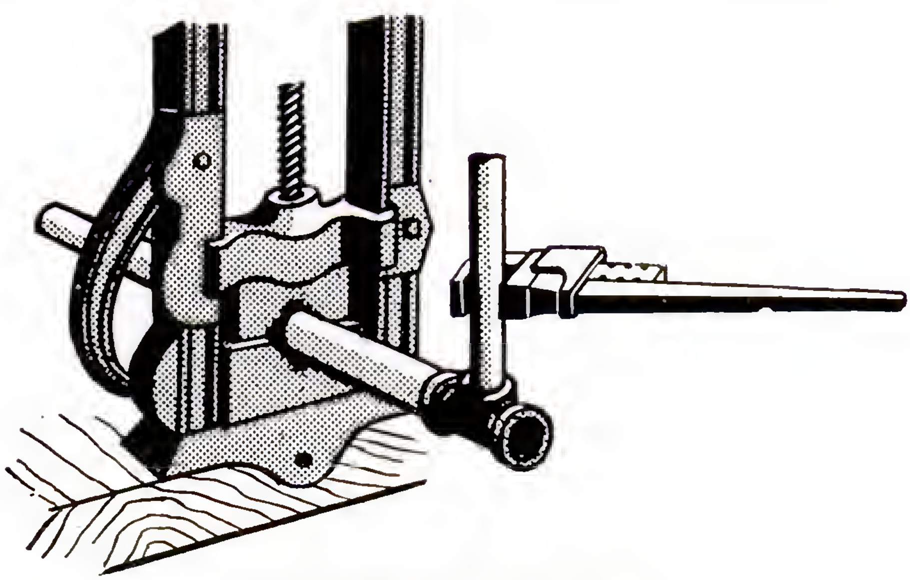


Figure 105.—Fitting a pipe joint.

sealed with graphite paint. Put the sealing compound on the pipe threads only—so it won't get inside the pipe and form a dangerous obstruction. Make sure the threads are clean before you apply the sealing compound.

Threaded joints should be screwed together by hand and tightened with a PIPE WRENCH—commonly called a "Stillson." The pipe should be held in a pipe vise during assembly, but if it's impossible to use a vise the pipe may be held with another pipe wrench.

How tight should you tighten a joint? Experience is the best teacher. Usually you will have two or three unused threads on a properly cut pipe thread. If all the threads are used, the wedging action of the tapered thread may cause the fitting to split.

Pipe wrenches are made in a number of sizes (lengths). Use the following table as a guide for selecting the best size to use—

WRENCH SIZE	for	PIPE SIZE
6 inch		¼ inch
10 inch		⅜ and ½ inch
14 inch		¾ inch
18 inch		1 and 1¼ inch
24 inch		1½ and 2 inches

CHAIN PIPE TONGS are often used for turning and holding pipes of all sizes. One type of pipe vise utilizes the chain clamping principle.

TUBING TIPS

Tubing serves in dozens of places aboard ship to convey water, fuel, lubricating oil, hydraulic fluid, etc. Copper tubing is used extensively, but some tubes are made of brass, stainless steel, Monel or aluminum alloys.

Because tubing is usually thin-walled, it is seldom threaded. Special threaded FITTINGS and COUPLINGS are generally used with tubing. These are either soldered to the tubing or held by a flared end. Pieces of tubing may be soldered together without the use of a fitting. Hard solders (usually silver solders) are best. Soft solders are not strong enough.

Tubing is usually supplied in coils in the soft (annealed) condition.

A straight line may be the shortest distance between two points but it's not the best distance for tubing lines. It's almost impossible to cut and flare tubing so that it will be exactly the required length. And a straight

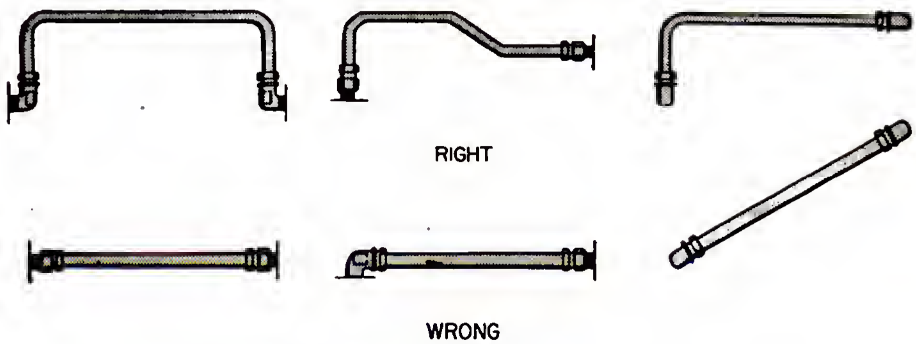


Figure 106.—Use the right installation method.

tube would be easily damaged or pulled loose by an accidental blow, or by expansion or contraction resulting from temperature changes. Figure 106 illustrates the RIGHT and WRONG methods of tubing installation.

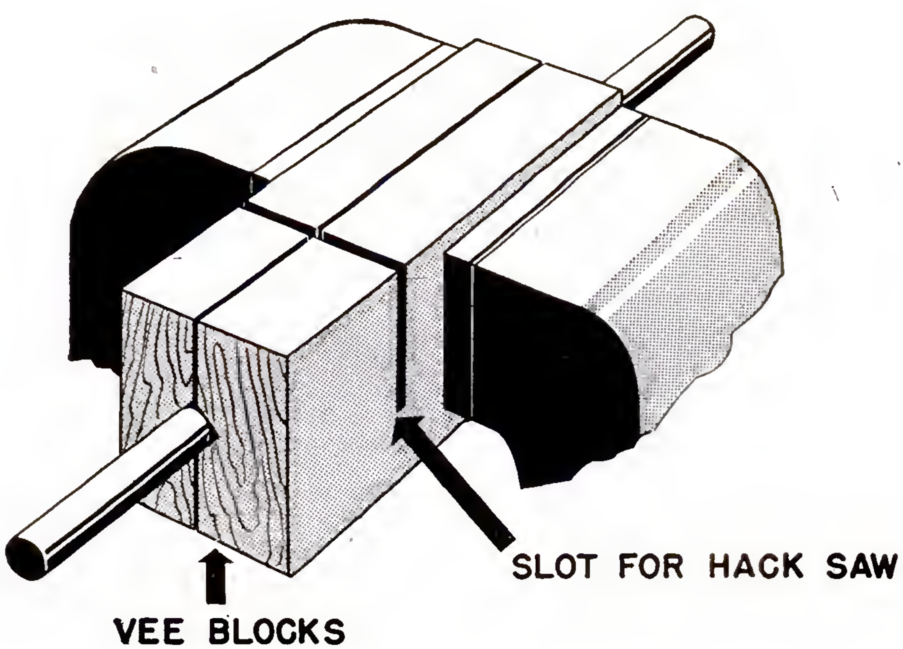


Figure 107.—Set-up for sawing tubing.

CUTTING TUBING

You can do a good job of cutting tubing with a hand hack saw if you use the set-up shown in figure 107. Always use a blade with 32 teeth per inch for sawing thin tubing. But use a TUBE CUTTER if you have one.

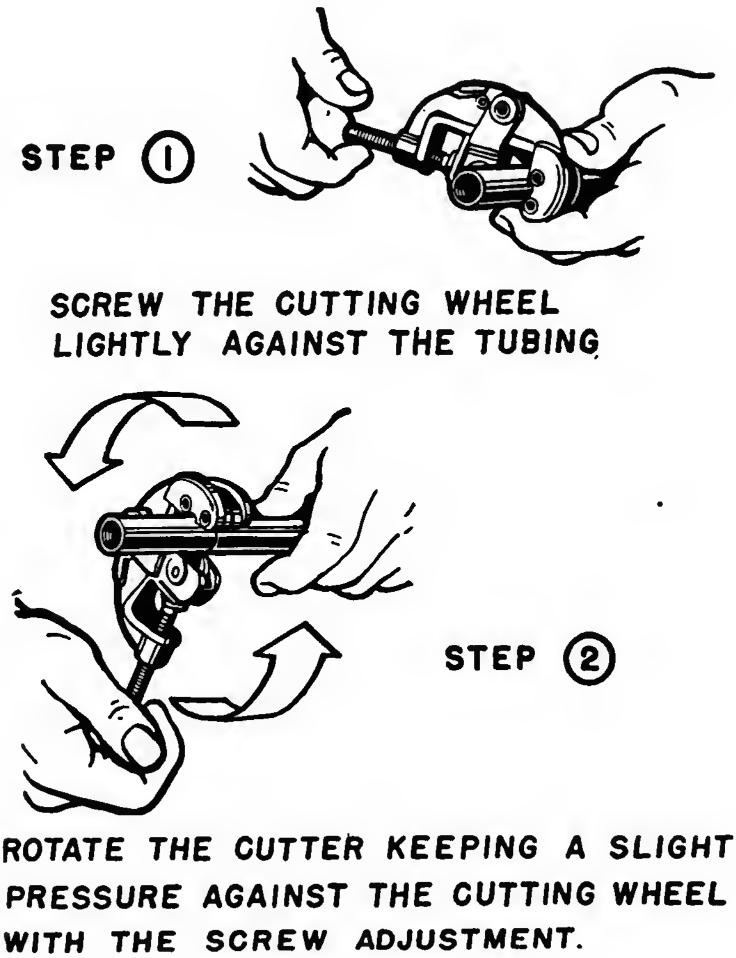


Figure 108.—Tube cutter.

It's a miniature version of a pipe cutter. The tube cutter works as pictured in figure 108. Be sure you operate the cutter in the direction indicated by the arrows. To avoid crushing the tubing, turn the handle only a short distance after each revolution.

After the tubing is cut to length, square up the ends and remove the burrs. The outside burrs may be removed with a file. The inside burrs may be removed with a bearing scraper, a knife, or a small file. AVOID NICKS AND SCRATCHES—they are the beginnings of potential cracks.

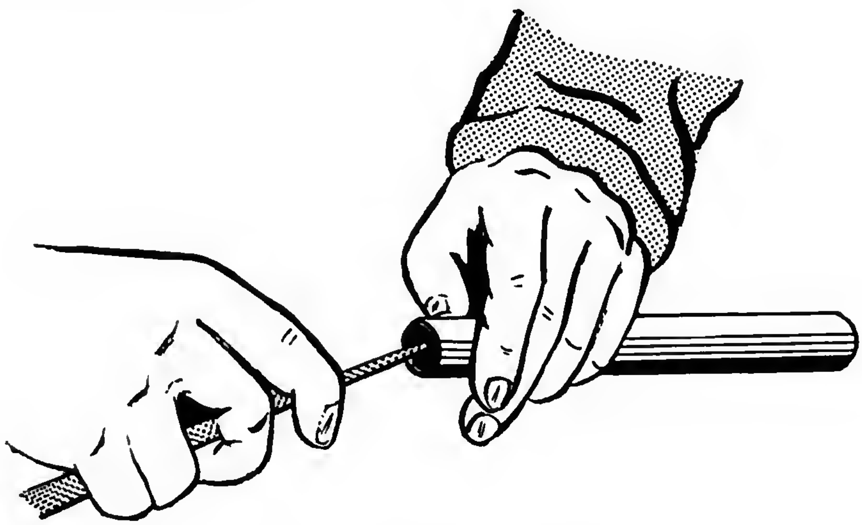


Figure 109.—Burring tubing.

The next thing to do is to hold a field day on the tubing. Get out ALL the filings, chips, dirt, etc. Stubborn dirt or scale can be removed by running a piece of "fuzzy" wire cable through the tubing.

BENDING TUBING

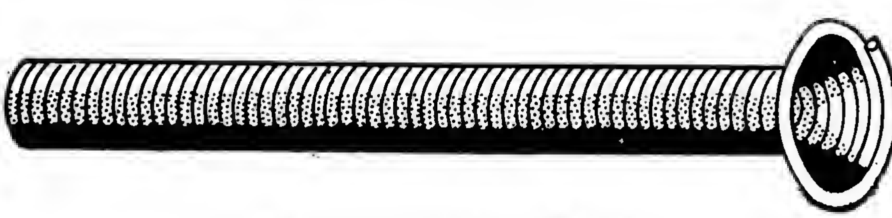


Figure 110.—Coil wire tube bender.

After the tubing has been cut, squared, burred, and cleaned, it's ready to be formed (bent) to the desired shape. You can bend tubing by hand, but you do a better job if you use some kind of bending device.

Small sizes of tubing, like those used for engine fuel and oil lines, may be formed with the SPRING COIL TOOL shown in figure 110. A coil is selected that just fits over the tubing. The tool helps to prevent the collapse of the tube and produces a smooth curve.

Medium size tubes ($\frac{1}{4}$ to $\frac{5}{8}$ inches) may be formed with the HAND TUBE BENDER. The use of this tool is pictured in figure 111.

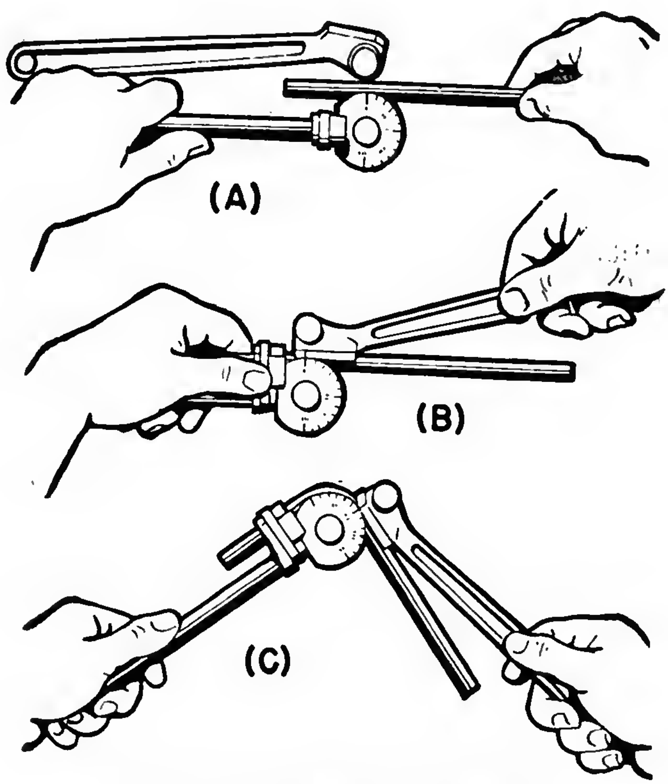


Figure 111.—Hand tubing bender.

Tubing over $\frac{1}{2}$ inch in diameter will partially collapse during the bending process IF it is not filled with some kind of easily removable material. Filler materials include sand, resin, and special bending alloys which have very low melting points.

SAND is a commonly-used filler. It must be fine and dry, and be packed tightly in the tube. It is not necessary to heat the tubing, but it should be in the annealed condition.

Commercial BENDING COMPOUNDS are more expensive than sand or resin but they may be used over and over—indefinitely, if not overheated. They melt at a temperature of 150° F., and should be melted in a ladle or in boiling water. The tubing should be preheated before the melted compound is poured in.

RESIN is used in much the same way as the special bending alloys. The resin is melted in a ladle and poured into the plugged and preheated tube. If the tube is not preheated the resin will harden before it reaches the plugged end of the tube. Allow the resin filler to cool to room temperature before you bend the tubing.

> CAUTION: When you are ready to melt out a filler material, apply the heat FIRST TO THE OPEN END of the tube, and then move the heat along the tube as the melting filler runs out. If you forget to start at the end there is danger of an explosion—especially if resin is the filler material.

How can you straighten a piece of tubing that is dented or flattened? One way is to connect the tubing to a compressed air line and tap it into shape with a mallet. You must, of course, anneal the tubing for best results. To straighten a length of tubing, just roll it on the bench top with your hands.

Tubing that is subject to vibration should be annealed again after bending, as the bending process hardens the metal. Annealed tubing will absorb vibration shocks.

FLARING

FLARING (or BELLING, as it is sometimes called) is the stretching of the end of the tubing into a funnel shape so it can be held by a fitting. Figure 112 shows how a flared end is held by two different types of fittings.

Before you flare BOTH ends of a tube, be sure you have all the necessary fittings ON the tube. If you

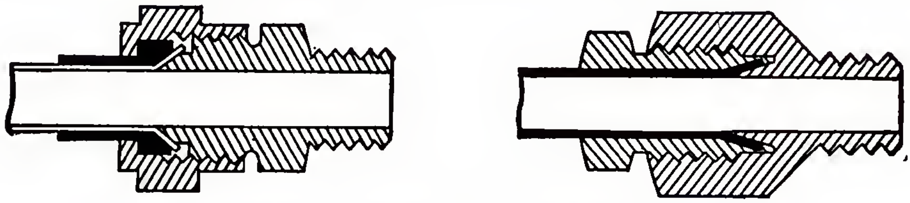


Figure 112.—Triple and standard fittings.

don't, you'll get the old "razzberry" from your shipmates. Fittings won't slip over a flare.

There are several types of tools for forming flares. The use of the BALL TYPE is illustrated in figure 113.

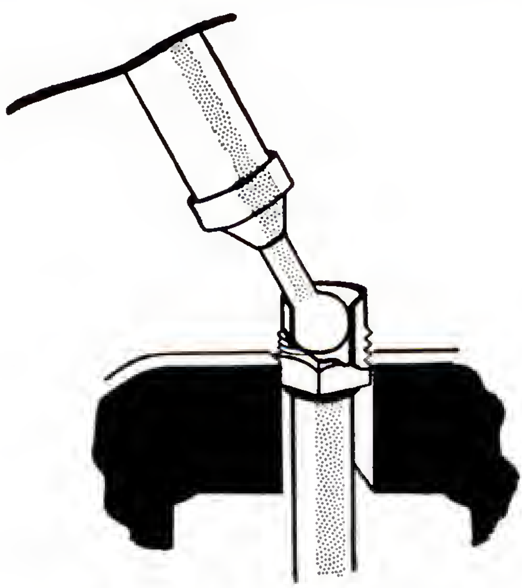


Figure 113.—Ball type flaring tool.

It's recommended for thin wall, soft copper or aluminum tubing not over $\frac{3}{4}$ inch in diameter.

The flaring tool shown in figure 114 is a good one for general use, because it's a combination outfit that will flare several sizes of tubing. Another type is similar to the hammer type—except that it's not hammered. Its cone-shaped anvil is forced against the end

of the tubing by a threaded rod with a T-handle which screws through the clamp head.

The STANDARD and TRIPLE HAMMER TYPES of tools are designed for sizes up to 2 inches in diameter. The standard type is used with a two-piece fitting; the triple hammer type on either two or three-piece fittings. Each size of tubing requires a separate tool.

The important points to keep in mind are the LENGTH of the flare, the SQUARENESS of the end, and

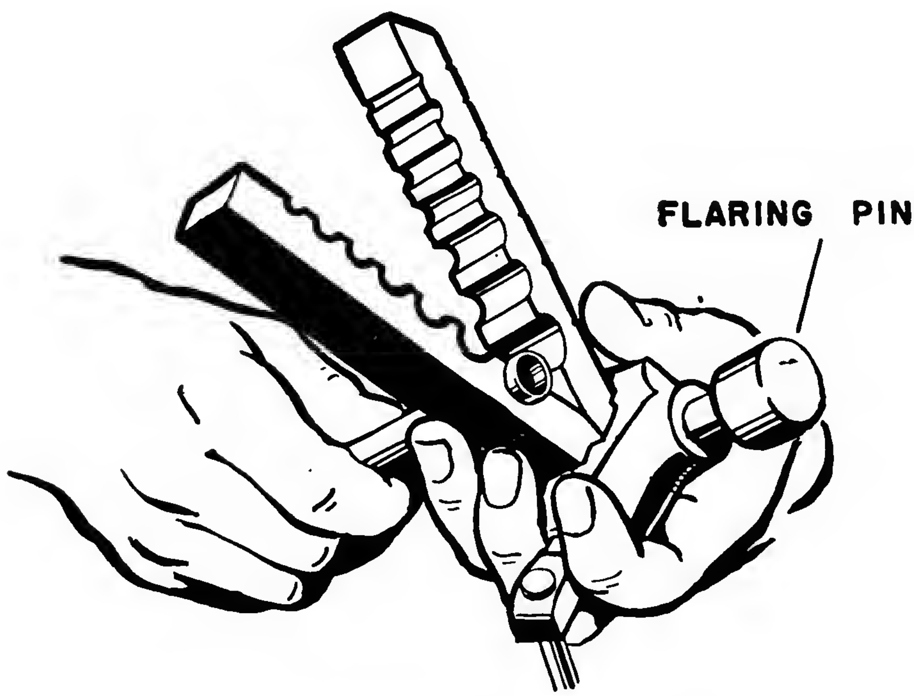


Figure 114.—Hammer type flaring tool.

the FIT of the flare against the fitting. In addition, you must avoid cracks, dents, pocks, and scratches on the flared surface.

The tubing flare and the fitting must form a joint that's TIGHT and STRONG. Figure 116*A* shows a good flare. The views at *B* show you how the ANGLE and RADIUS of the flare should match the contour of the fitting seat.

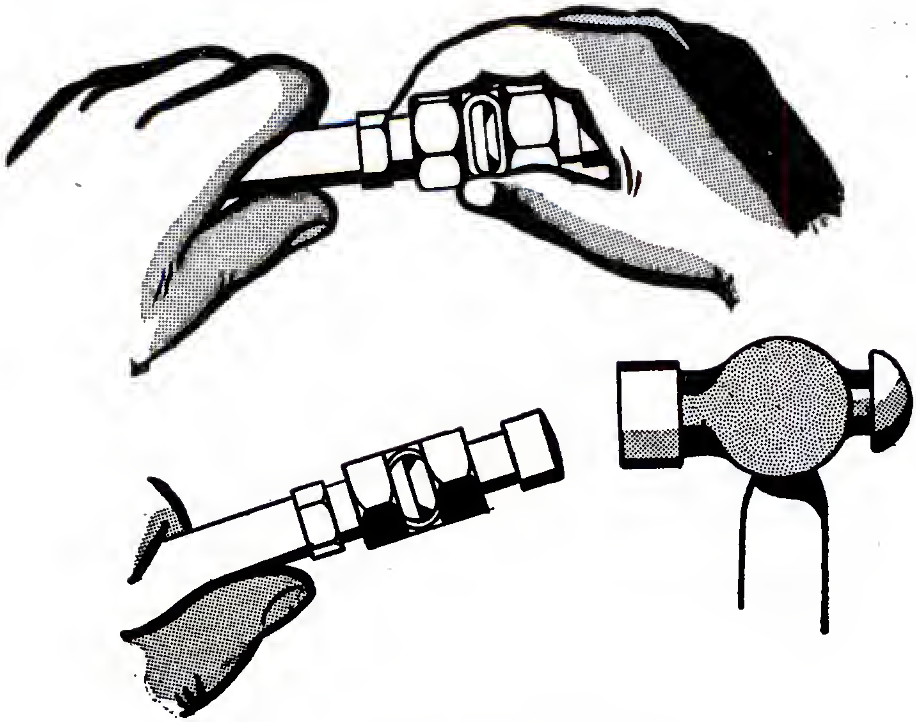


Figure 115.—Triple type flaring tool.

If a flare is too short, the full clamping area of the fitting is not utilized. Because of the small area of the tube that is clamped, the flare may be squeezed thin and weakened. Such joints do not provide maxi-

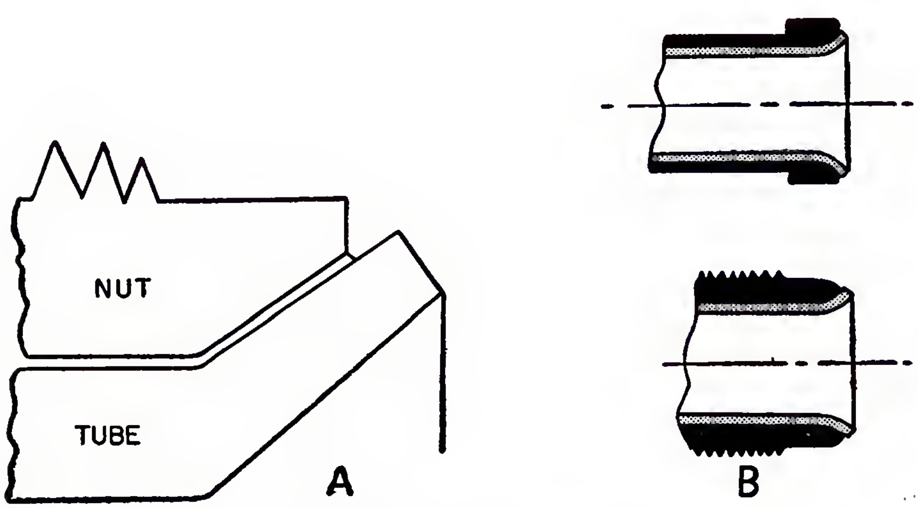


Figure 116.—Correct flares.

Soldered fittings involve the use of a UNION TAIL (or sleeve) which is soldered over the end of the tubing. No flare is required. SILVER SOLDER, or another hard solder, is used so the joint will be strong. A soldered fitting is shown in figure 118.

TUBING ASSEMBLY

All joints of tubing should be tested under pressure before they are installed. Repair shops are equipped to make these tests under conditions similar to those under which the installation will eventually be used.

Before you install or replace a piece of tubing, make sure that its interior is CLEAN. All foreign material —chips, dust and scale—must be removed. This is particularly true of the tubing used for HYDRAULIC lines of ordnance equipment. Those lines must be CLEAN, because they contain delicate and sensitive valves.

New tubing is supposed to be clean, but the Navy takes no chances—it's cleaned again, and thoroughly. Here are the CLEANING DIRECTIONS for COPPER TUBING and pipe, as specified by BuOrd for hydraulic lines—

1. Treat machined faces or threads of end fittings with hot paraffin wax.
2. Dip in an acid bath solution (and remove immediately). The solution should be 2 parts sulphuric acid, 1 part nitric acid, and 4 parts fresh water.
3. Wash in fresh water.
4. Immerse for 1 minute in a neutralizing bath of 1½ lbs. of Magnus No. 2 per half gallon of fresh water.
5. Soak in boiling water for 10 minutes.
6. Pass a frayed wire rope through the pipe.
7. Wash with stream of fresh cold water at high pressure.

8. Dry thoroughly, being careful not to leave threads of rags, toweling, or waste in the pipe or tube.
9. SEAL BOTH ENDS UNTIL READY TO INSTALL.

Never spring or force tubing into position—it must be bent to fit so that the threads of the fittings are perfectly ALINED. If a cement is to be used on a joint, start the threads about three turns before applying the cementing material. The TINNING of the OUTSIDE THREADS of a hydraulic line fitting produces a superior seal.

Avoid leaving any dirt or other foreign matter in a line. Plug the open ends of tubes and pipes if any drilling, filing, welding, or soldering, is done near them.

To sum it all up, tubing and pipe joints must FIT, and the line must be kept CLEAN, TIGHT, and STRONG.

CHAPTER 9

SOLDERING AND WELDING

SOLDER

It's spelled S-O-L-D-E-R but pronounced SOD-ER—just leave out the L when you say it. SOLDER is used to join pieces of metal, to make metal joints and seams leak-proof, and to join electric wires so they will be good conductors.

SOFT SOLDER is the kind you use most often on sheet metal and electrical wire. It's usually 50 percent tin and 50 percent lead and is known as "half-and-half" solder. It is manufactured in both bar and wire forms. Some wire solders have hollow centers which are filled with acid or rosin core fluxes. The bar solders are cheapest, and the core solders the most expensive.

Soft solder (50-50) begins to melt at a temperature of 358 degrees F. and become a liquid at 415 degrees. It does not have much strength, and should never be used where heavy strains and stresses will be applied

to the soldered parts. Solders containing 55 percent to 70 percent tin are stronger, and can stand more strain than half-and-half solders, but no soft solder approaches the strength of the hard solders.

HARD SOLDERS are made of alloys of copper, zinc, silver, and tin. They are much stronger than the soft solders and will withstand considerable strain, pressure, and vibration. They may be used to solder high-pressure pipe connections, gasoline and oil pipe joints, and broken band saw blades. These hard solders must be melted with a blow torch or welding torch—soldering coppers do not conduct enough heat to melt them.

SOLDERING COPPERS

SOLDERING COPPERS, sometimes INCORRECTLY referred to as "irons," are used for small soldering jobs.

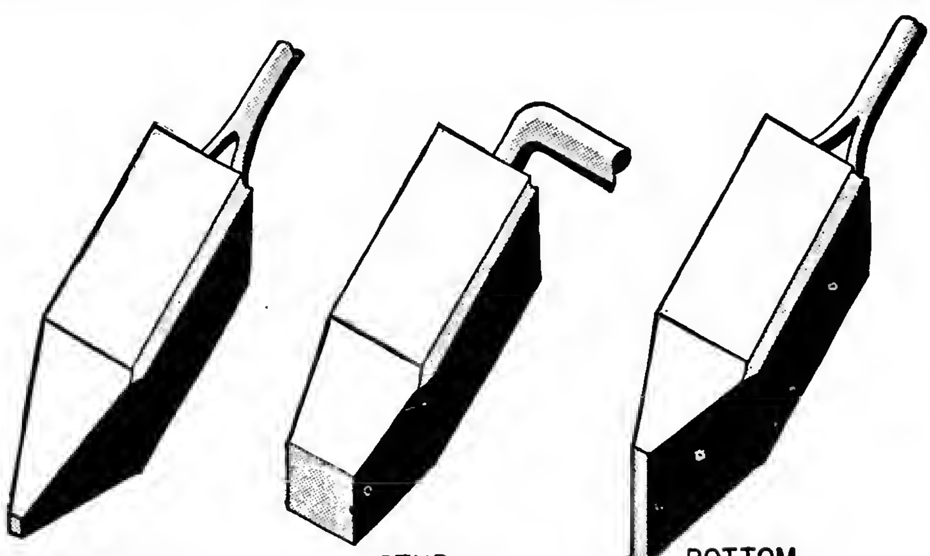


Figure 119.—Soldering coppers.

The working end of such a soldering tool is made of copper because that metal is an excellent conductor of heat.

The SIZE of soldering coppers is determined by the weight of a PAIR of coppers. That system is used be-

cause a workman needs TWO coppers of the same size at one time—one being used while the other is heating.

The 2-pound and 3-pound sizes are most frequently used. You select the size to use according to the requirements of the job. As a general rule, it's best to pick the largest size that's convenient to handle.

The POINTS of soldering coppers should be rather blunt for efficient heat conduction. The points are shaped by forging—beating them into shape on an anvil while they are red hot.

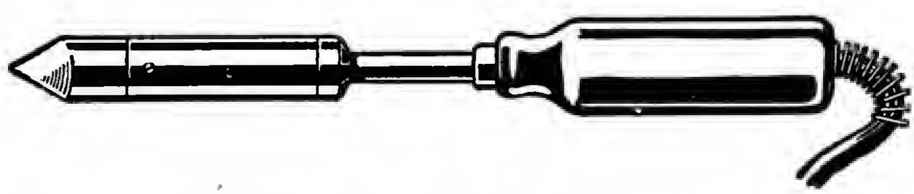


Figure 120.—Electric soldering copper.

The ordinary POINTED copper is used for utility work. A BOTTOM copper is best for soldering the seams of buckets, pans, trays, etc. The STUB copper is used for flat seams requiring considerable heat. An ELECTRIC copper, with interchangeable tips, may be used for light work and is especially good for work on electrical connections.

HEATING THE SOLDERING COPPERS

If you have access to a GAS OVEN you will use it to heat your soldering coppers. These ovens have one, two, or three burners, on which the heat may be manually controlled by valves. Heated coppers are ready to use when they cause the gas flame to burn with a green color. Overheating must be avoided, as it softens the copper and burns away the film of "tin" on the surfaces of the point.

When you use a gas oven, be extremely careful

about lighting the gas. You'll play safe if you twist up a piece of paper, light it, place it on or near the burner, STAND CLEAR, and then turn on the valve. Make SURE that a valve does not leak when you turn it off.

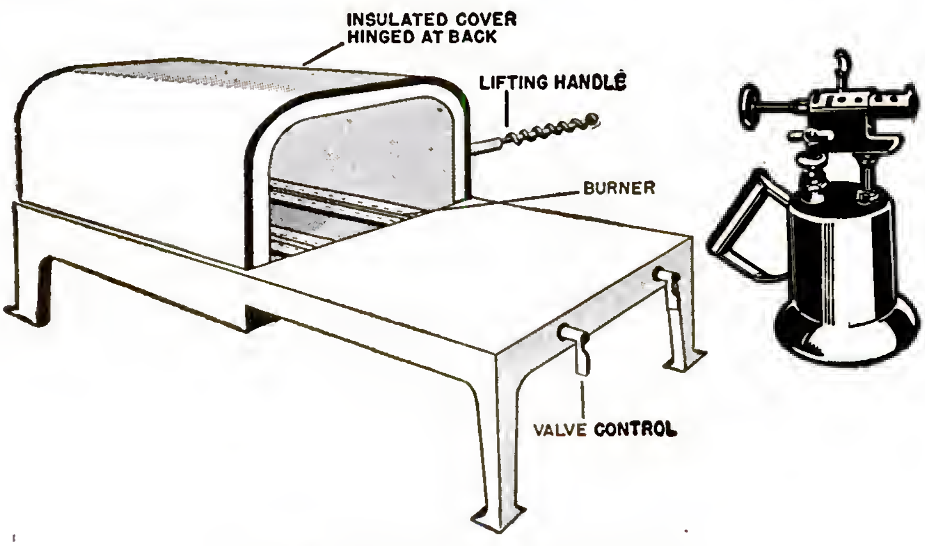


Figure 121.—Gas oven; blowtorch.

Soldering coppers are often heated with a gasoline BLOWTORCH, especially when a soldering job must be done away from the shop, and when an electric copper isn't satisfactory.

The operation of a blowtorch is simple. The tank is filled with clean, UNLEADED gasoline. Use the pump to build up enough pressure in the tank to cause the gasoline to flow when the valve is opened.

With the valve open, liquid gasoline will flow from the jet opening and drip into the priming pan. When the pan is almost full, close the valve and ignite the gasoline with a match. The flame from this burning gasoline heats the perforated nozzle. When most of the gasoline has burned and the nozzle is hot, open the valve slightly to allow the gasoline vapor to escape. The vapor burns with an almost colorless, light-blue flame. By using the valve, you can adjust the flame to the desired intensity. A yellow or red flame is not

as hot as a blue flame, and will not heat efficiently. The flame will be blue if the nozzle is hot enough to completely vaporize the gasoline.

Very little maintenance is necessary with the gasoline blowtorch, providing you use only clean, unleaded gasoline. Leaded gasoline tends to stop up the passages and valves. This condition must be avoided as it is almost impossible to clean these parts thoroughly. NEVER use TURPENTINE in a blowtorch.

When you close a blowtorch valve, don't use much force. Remember that the metal around the valve is hot. It will contract when it cools, and the valve will be extremely tight. In fact, it may be stuck so tight that you can't open it with your hands alone.

No matter what method you use to heat the copper, avoid burning the point. Direct the flame at the BACK of the copper, NOT at the tip. The heat will be rapidly conducted to the point.

The PLUMBER'S FURNACE works on the same principle as a gasoline blowtorch. It has a shield that protects the flame from the wind. A crucible (pot) is used with the plumber's furnace for melting solder, lead, bearing metals, and other alloys and metals having low melting points.

FLUXES

A FLUX is a chemical preparation (powder, paste, or liquid) used to keep the metal clean so the solder will stick to it. If a flux is not used, the heat will cause OXIDES to form on the metal surface and prevent the solder from adhering firmly.

The usual fluxes for common metals are:

Brass, copper, tin	Rosin.
Lead	Tallow, rosin.
Iron, steel	Borax, sal-ammoniac.
Galvanized iron	Zinc chloride.
Zinc	Zinc chloride.
Aluminum	Stearine, special flux.

Fluxes are either CORROSIVE or NON-CORROSIVE. The commonly-used corrosive fluxes, ZINC CHLORIDE and SAL-AMMONIAC, eat away and corrode the metal if allowed to remain on it after soldering. They should be completely removed by a thorough washing after you've finished a job. It is for this reason that ROSIN, a non-corrosive flux, is used when soldering electrical connections. The rosin is used in powdered form, or as a liquid core for wire solder.

You can manufacture your own zinc chloride by adding scraps of zinc to muriatic acid or hydrochloric acid. After the zinc has dissolved, the acid may be weakened to the correct strength by pouring IT into an equal amount of water. The resultant liquid really is zinc chloride, but you may hear it called "cut-acid" or "killed acid"—those are its shop names. It's dangerous to pour water INTO acid so always remember to pour the ACID INTO the WATER. As acid fluxes eat away metal, they must be used and stored in pottery or glass containers.

PASTE FLUXES, commercially manufactured, are usually available in one-pound cans. They contain grease for counteracting corrosion. This grease sticks to the metal and collects dirt. Paste fluxes are substitutes for the acid fluxes. They are safer to use, and are particularly useful for odd-job soldering, or at times when it's inconvenient to mix and use zinc chloride.

TINNING A SOLDERING COPPER

Soldering coppers must be TINNED before they will do a good job of soldering. TINNING is the process by which the copper point is coated with solder to prevent oxidation of the copper when heated. You can't do a good job of soldering with a poorly-tinned copper. You need to learn the TINNING PROCEDURE—just in case the man who used the copper last was careless and burned off the "tin."

Here are the steps to follow for tinning a soldering copper—

1. File the faces of the point until they are smooth and flat.

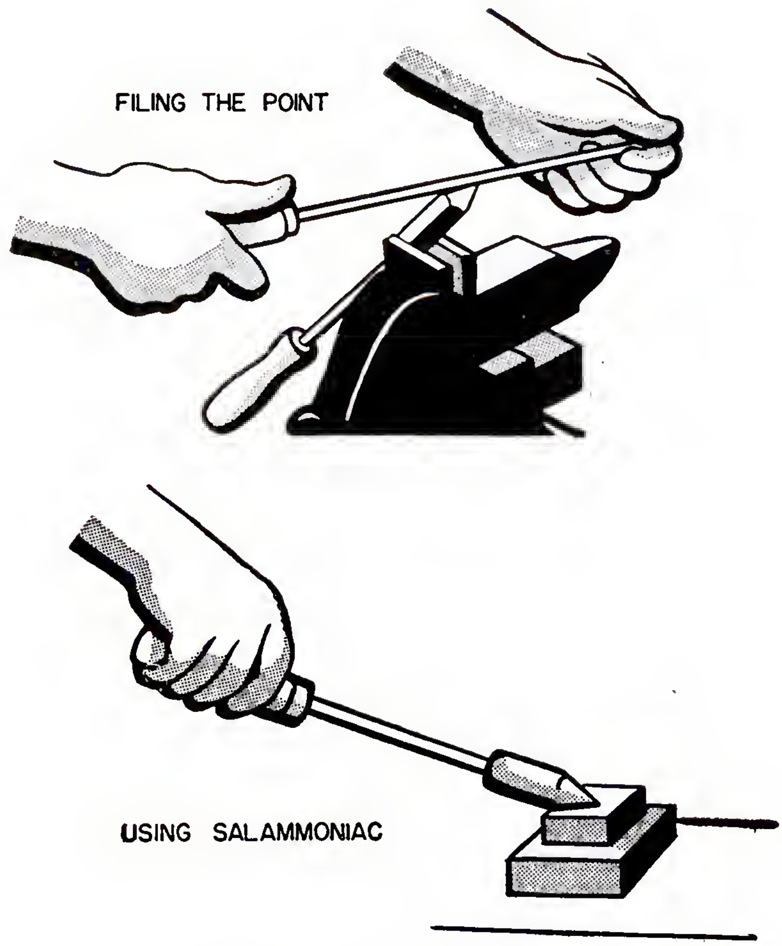


Figure 122.—Steps in tinning.

2. Heat the copper hot enough to melt the solder readily.

3. Rub the faces of the point on a sal-ammoniac brick, or in sal-ammoniac powder, while the point is hot. Avoid breathing the fumes from the hot sal-ammoniac because they cause headaches and injure the lungs.

4. Apply a small amount of solder to the point as you rub it on the sal-ammoniac. The solder will form a thin, bright film (called "tin") on the faces of the point. This film will "stay put" unless you overheat it.
5. Reheat the copper and it's ready to use.

Powdered rosin can be used instead of sal-ammoniac for tinning, but rosin will work better if a small amount of sal-ammoniac powder is added to it.

DIPPING SOLUTION

When you heat a soldering copper, the tinned tip will be covered with scale (oxides) by the time it is hot enough to use. To remove this scale, you can dip the tinned copper point into a DIPPING SOLUTION, made of one part of sal-ammoniac powder mixed with 40 parts of water. Only the point of the copper should be dipped into the solution and it should be quickly withdrawn. The tinned point will emerge bright and clean.

NEVER dip your soldering copper into zinc chloride or other acid solution. The acid may spatter into your eyes, onto your skin, and over your clothes. If it does, you'll suffer burns, and you may be blinded. The acid will also eat pits and holes in the soldering copper, thereby shortening its useful life.

SWEAT SOLDERING

In sweat soldering, the contacting surfaces of two pieces of metal must be tinned—that is, coated with solder. The surfaces are then placed together and heated with a large copper which "sweats" them together. Use plenty of flux for a good job of sweat soldering. Fittings, lugs, and electrical terminals are easily sweated on if the contacting parts are tinned first. The strength of a sweated job depends on the FIT and CLEANLINESS of the pieces joined.

SOLDERING PROCEDURE

Ordinary soldering is done by heating the METAL to a temperature that will melt the SOLDER, and then applying the solder to it. Here are some definite procedures that you must follow to insure a strong, neat soldering job—

1. CLEAN THE SURFACES to be soldered. (Solder will not stick to dirt or grease, and the heat and flux won't remove all of it.)
2. USE WELL-TINNED COPPERS — two of them. Keep one heating while you're soldering with the other.

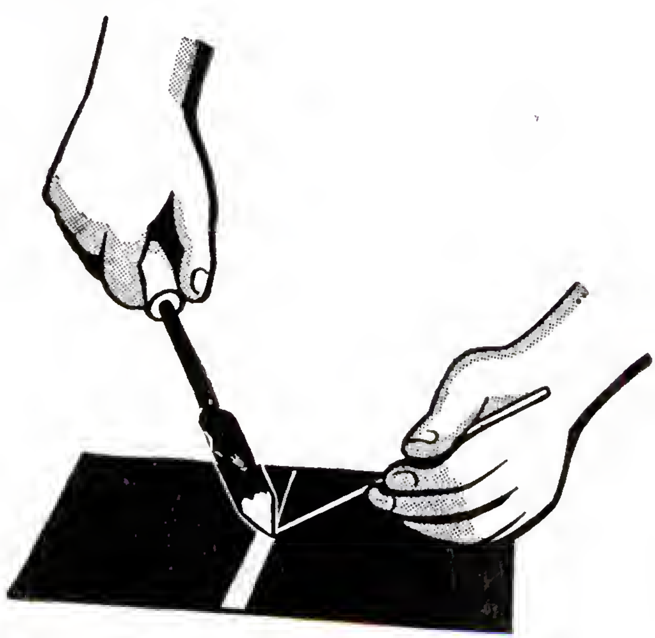


Figure 123.—Flow the solder.

3. Use the PROPER FLUX.
4. CONTROL THE HEAT. Don't allow your coppers to overheat, but have them hot enough to melt solder readily.
5. Keep the soldered surfaces CLOSE TOGETHER to insure a strong bond, seam, or joint.

6. DON'T HANDLE or move a soldered job until the solder has "set" and has partially cooled. Solder is weak and brittle during the process of solidification.

The ideal way to apply the solder is to FLOW IT ON. No soldered joint or seam will be satisfactory if the solder is just "stuck on" or melted on.

To get the solder to FLOW on, you must PREHEAT the surfaces to be soldered. These surfaces should be hot enough to melt the solder. The soldering copper will do the preheating if it's pulled SLOWLY along the seam, as pictured in figure 123. Notice that the solder is added TO THE SEAM, and that the copper is held in such a manner that it heats the metal in ADVANCE of the flowing solder. Keep one face of the copper FLAT AGAINST THE WORK, so the heat will be conducted rapidly to the metal.

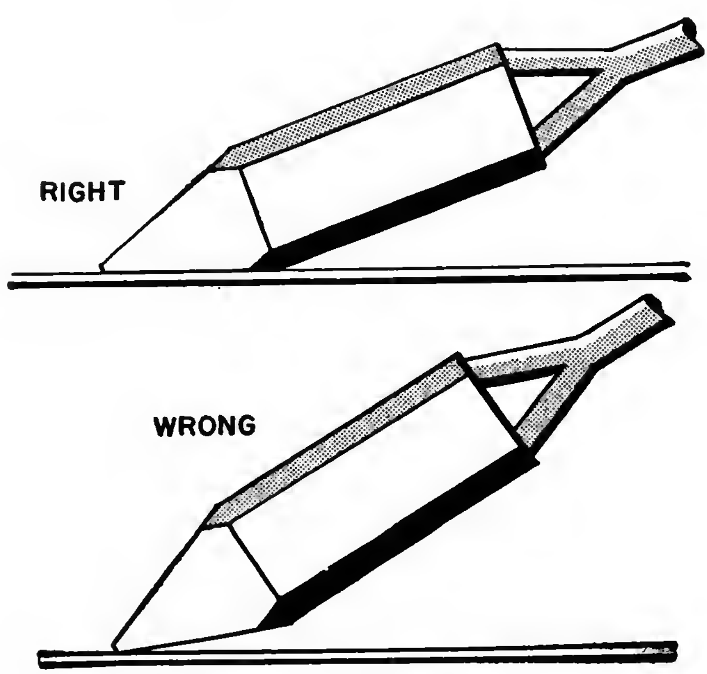


Figure 124.—Hold it flat.

You'll find that it's easier to solder a sheet metal seam if you "tack" it first. Figure 123 shows the cop-

per approaching the last "tack." After flux has been applied with a brush or swab, the "tacking" can be done with small drops of solder. Such drops may be readily picked up with the tip of a properly tinned soldering copper.

SOLDERING ELECTRICAL CONNECTIONS

The soldering procedures for sweat soldering and "flow-on" soldering also apply to the soldering of electrical wires and fixtures. One important thing to

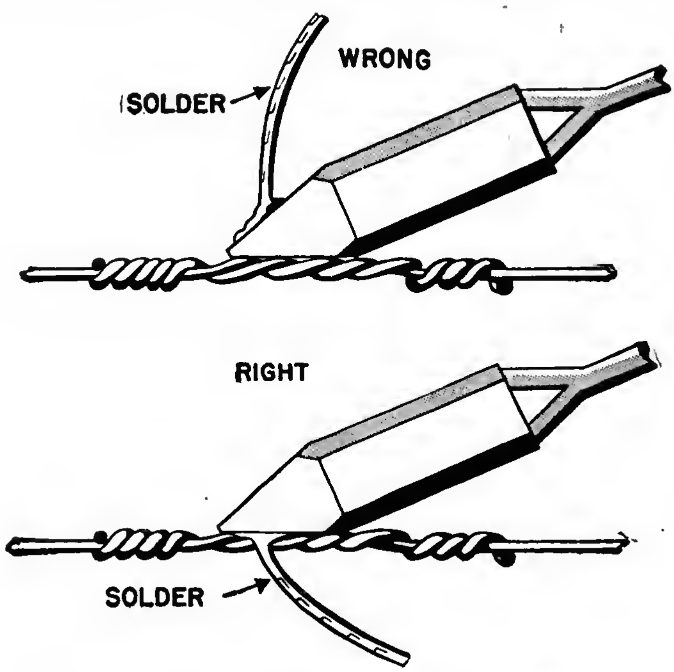


Figure 125.—Applying core solder to a splice.

remember is to use ROSIN as the flux. Rosin is non-corrosive, and burned rosin does not leave a residue that will collect moisture, dust, dirt, and lint. This is an important feature when you're soldering radio, radar, sound, and switchboard equipment.

Apply core solder (rosin core) to a splice, NOT to the soldering copper. The wires should be heated hot enough to melt the solder. The soldering copper merely serves as a heating device.

You can SWEAT a terminal lug to the end of an electric cable. Clean the exposed end of the cable and tin it. Then clean the socket, add flux, and fill it with molten solder. Pick up the cable and force the tinned end firmly but slowly into the socket of the lug. After insulation tape is added, it will be like view *B*, in figure 126.

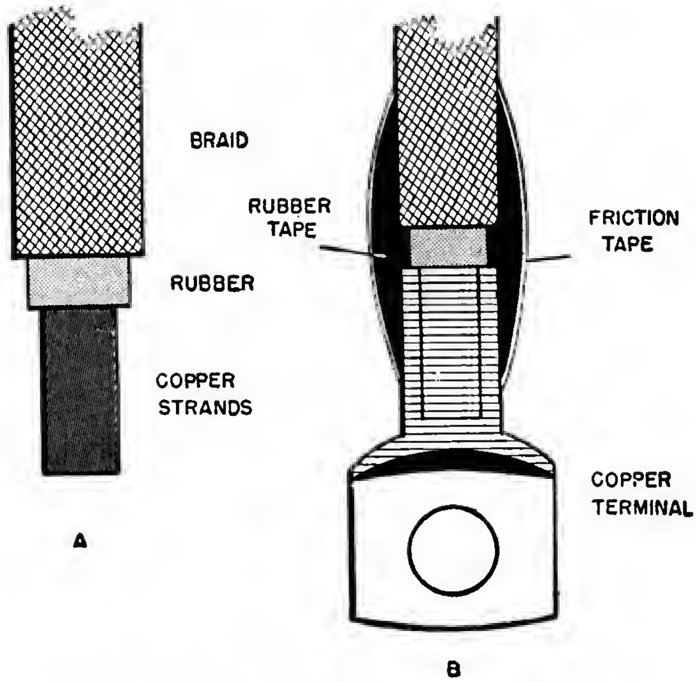


Figure 126.—Sweating terminal lug on cable.

Allow the soldered parts to "set" and cool before you handle them, and don't try to hold them in your hands while they cool. You may "jiggle" them and break the joint loose before the solder has cooled enough to acquire its full strength. Remember that solder is brittle, and lacks strength while it is changing from the molten state to the solid state.

DIRECT FLAME SOLDERING

You can do SOME soldering jobs more easily and efficiently with a DIRECT FLAME than with a soldering copper. The flame of a gasoline blowtorch can be used

on certain large jobs, but on small jobs, you'll have better luck with a GAS BLOWPIPE or an ALCOHOL TORCH. These tools are DESIGNED for direct flame soldering.

The gas blowpipe looks like a welding torch's little brother, and it works on the same principle. The blowpipe part of it is a tube within a tube. One tube fur-

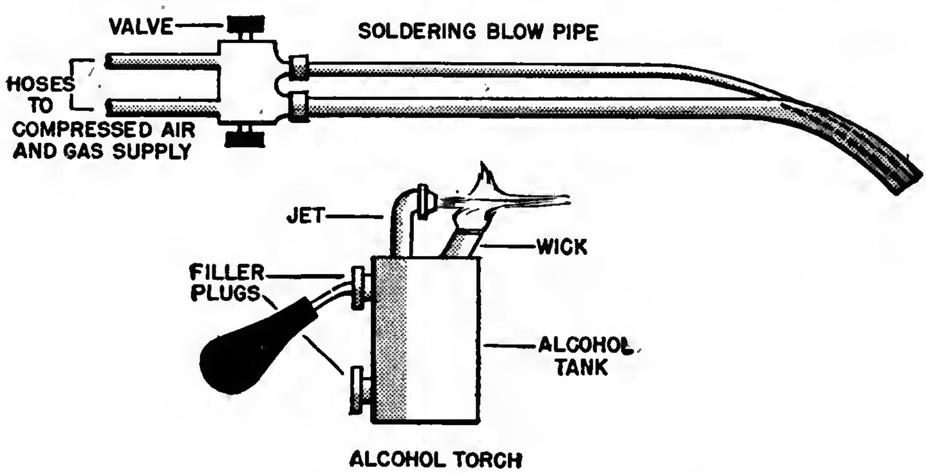


Figure 127.—Blowpipe and alcohol torch.

nishes the gas, either natural or manufactured, for the flame. The other tube supplies compressed air or oxygen.

The automatic alcohol torch, also shown in figure 127, works on the same principle as the blowpipe except that it burns alcohol and is a self-contained unit. The alcohol torch does its own "blowing." The burning wick heats the jet tube, which causes the alcohol to vaporize. When a liquid is vaporized, it expands. This expansion continuously forces some of the alcohol vapor from the jet opening. There the vapor is ignited to form a hot, light blue flame.

SAFETY FIRST

Fuel for any heating equipment presents a dangerous FIRE HAZARD, so it must be used and stored with the greatest care. "Navy Regs" allows you to keep only small amounts in the shop.

Do not fill a blowtorch or an alcohol torch near an open flame or where a spark might ignite it.

Never solder a can or tank that has contained gasoline, alcohol, etc., unless it is first thoroughly steamed for several hours.

Be sure to disconnect an electric copper when you're through using it. Be careful WHERE you lay ANY hot soldering copper—it may start a fire or burn a shipmate.

WELDING PROCESSES

Have you ever seen a blacksmith make a FORGE WELD? When he wants to weld two pieces of steel together he heats them in a forge until they are soft and malleable. Then he lays them across an anvil and pounds them together with ringing blows of his hammer. Engineers call that type of welding PRESSURE WELDING. SPOT WELDING and SHOT WELDING with electricity are modern versions of the village blacksmith's forge welding. They are used where thin sections of metal need to be fastened together.

THERMIT WELDING is a method used to repair large castings and machinery parts. It requires a lot of preparation, as a mold must be constructed around the break. This mold is then poured full of SUPERHEATED, molten steel, which is so hot that it melts some of the surrounding steel of the broken parts and forms a strong fused union. Thermit welding is one form of FUSION WELDING.

You are probably familiar with the simpler and more commonly used methods of FUSION welding. The word "fusion" simply means that the parts are melted together, sometimes with the addition of extra metal. You have seen welders doing this work with OXY-ACETYLENE GAS TORCHES or with ELECTRIC ARC WELDING EQUIPMENT.

Electric arc welding is used for such jobs as welding the joints of large pipe lines, for repairing iron and steel castings, and for welding the structures and plates of ships and boats.

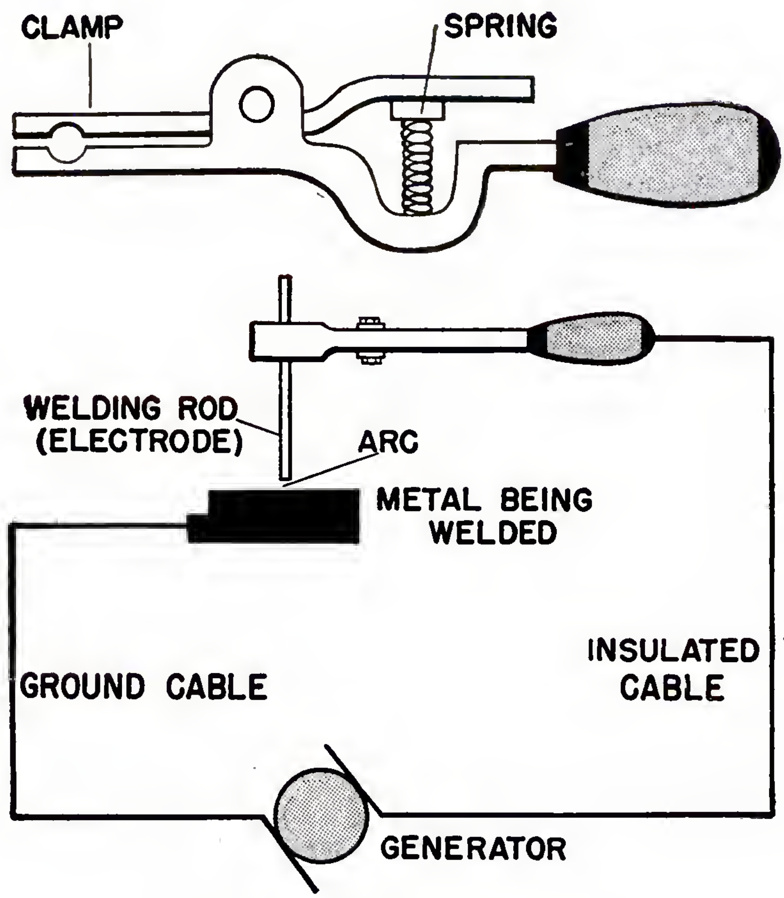


Figure 128.—Arc welding set-up.

Most arc welding is done with metal electrode filler rods which are coated with flux suitable to the job being welded. The electrode is held in a spring-jaw holder which is connected by a heavy insulated cable to the generator or other power source. To provide a return for the arc current, another cable—called the GROUND—connects the metal being welded to the power source. The ground cable has a clamp-type terminal for easy attachment and removal.

The end of the metal electrode and nearby portions of the metal being welded are melted by the heat of the arc, and they are thus fused together. The electrode supplies the extra metal that is usually required to make a strong weld.

The arc of arc-welding equipment really puts out the heat—about 5,000° F. A few minutes exposure to the ultra-violet rays of the arc and you'll have a "sunburn" that would take "Old Sol" all day to produce. And it will burn right through a tan, too. If you look at the arc, your eyes may hurt for several days. That's why you see an arc welder wearing a heavy face mask with a dark glass window. Arc welders also wear leather jackets and aprons to protect their bodies from the heat.

OXYACETYLENE WELDING

Oxyacetylene welding, usually called "gas welding," is done with a WELDING TORCH. The torch mixes the ACETYLENE and OXYGEN gases to provide fuel for the flame. Two heavy hoses are connected to the torch, one leading to the acetylene supply, the other to the oxygen supply. Portable gas welding units usually have high-pressure steel "bottles" of these gases mounted on a two-wheeled push cart. REGULATORS control the pressure released from the "bottles" to the hoselines. Valves on the torch regulate the amount of each gas that is released inside the torch, and control the mixture.

Large welding shops manufacture their own gas with generators, and pipe it to the various working stations. A working station usually is a bench with a fire-brick top. The bench is normally equipped with some type of vise, and other clamping and holding devices, for keeping metal parts in place while they are being welded. A drawer in the bench holds files, a hammer, a torch tip wrench, assorted sizes of tips for the torch and a scratch-type torch lighter.

Additional metal necessary for gas welds is obtained from a welding rod. Rods are selected by diameter, and the kind of material suitable to the welding job. Proper fluxes are used as required.

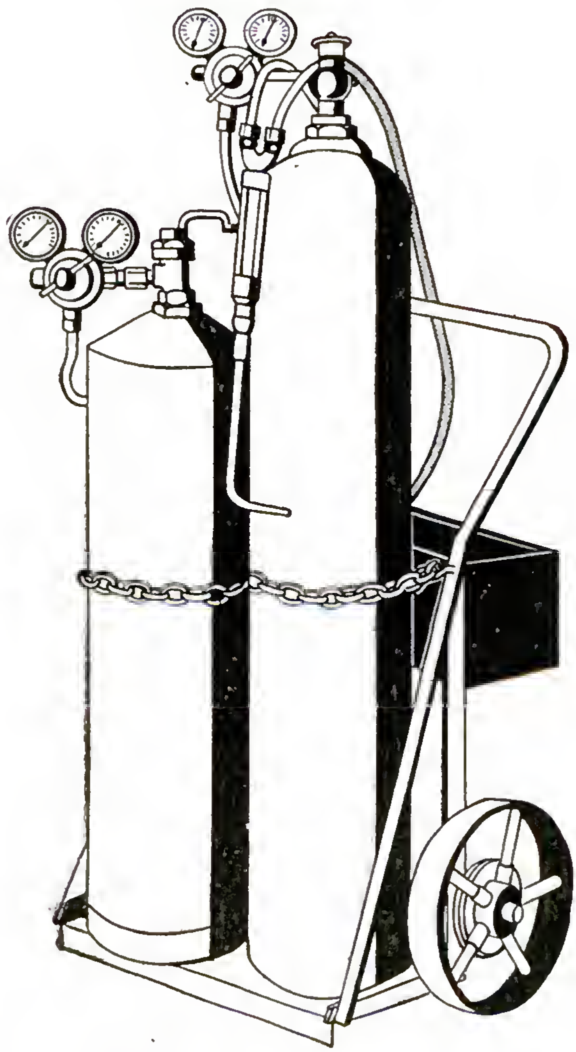


Figure 129.—Portable oxyacetylene welding outfit.

An oxyacetylene flame is capable of producing a maximum temperature of about 6,300° F. The size of the flame is regulated by the torch valves and by the size of the tip used on the torch.

BRAZING may also be done with a welding torch. BRAZING is a process by which two metal parts are

united by the addition of molten metal, but without fusion of the parts themselves. The filler metal, known as spelter, has a lower melting point than the metal being brazed. Most brazing is done on iron or steel parts with brass or bronze rod. The temperature required is from 1,700° F. to 1,800° F.

Silver solder, an alloy of tin, zinc, and copper, is also used for brazing. It melts at a temperature of from 1,160°-1,510° F. Powdered borax is used as a flux for brazing and silver soldering and commercial fluxes are available. Sal ammoniac may be used as a flux for brazing copper.

Parts to be brazed are heated to a temperature above the melting point of the brazing rod after the flux has been applied. The brazing-metal rod is then melted by the heat of the part, and the molten filler flows smoothly along the fluxed crack or joint.

Welding and brazing are not always done by hand. Factories, navy yards, and repair ships have automatic welding machines, which can be set up for special jobs.

Heavy sections of metal may be cut with a special gas cutting torch. These torches are operated by hand or mounted in automatic cutting machines. Special underwater welding and cutting torches are used by divers.

Don't expect to be allowed to use a welding torch just because you have read this chapter—it's only an introduction. Welding is a trade in itself, and a man must receive a lot of training and instruction—and do a lot of practice welding—before he can expect to "run" a satisfactory "bead."

Most welding aboard ships is done by rated Metalsmiths, so that's the rate for you if you want to be a welder.

CHAPTER 10

WOODWORKING WITH HAND TOOLS

MEASURING, MARKING, AND TESTING

Before you start working with wood you must know how to make measurements of thickness, width and length with a RULE. You'll probably use one of the types shown in figure 130. Handle rules with care. Be especially careful with the folding type, because its joints are easily sprung or broken.

You will use the MACHINISTS' STEEL rule frequently. Its use is explained in the Basic Blueprint Book. The rules and suggestions there apply to the use of ALL types of rules.

The TRY-SQUARE and the FRAMING SQUARE, also explained in the Blueprint Book, may be used for measuring, but their principal use is for laying out and checking right angles and straight ends and edges.

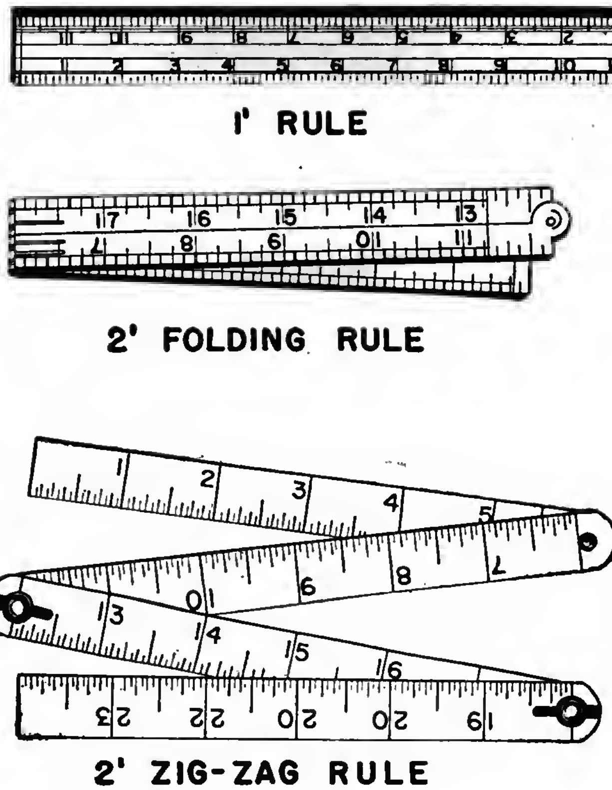


Figure 130.—Rules for woodworking.

The SLIDING T-BEVEL is used to lay-out and check angles. You can use a bevel protractor to set the T-bevel to the desired angle. Figure 131 shows how

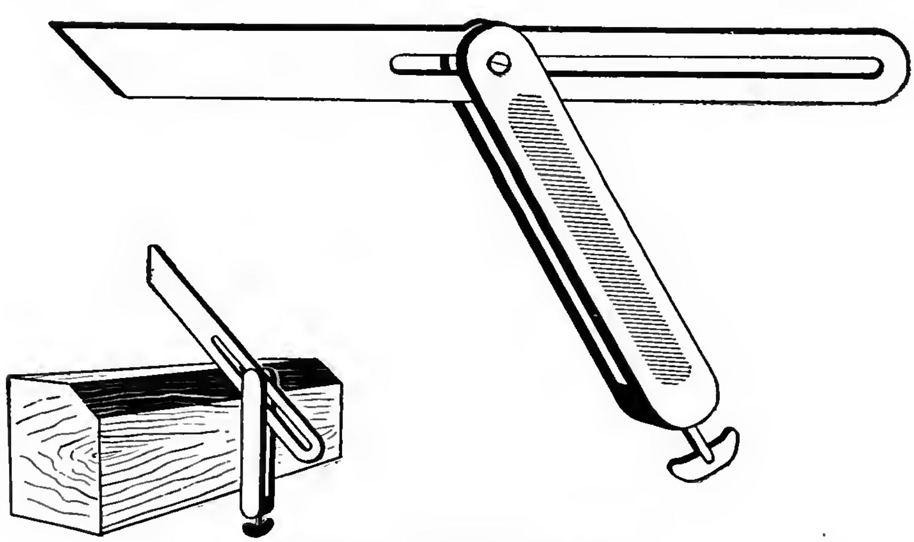


Figure 131.—Sliding T-bevel.

the T-bevel is used to check the angle of the chamfered edge of a board.

You should know the difference between a BEVEL and a CHAMFER. Examples of both are shown in figure 132. These terms are frequently used by wood-work-

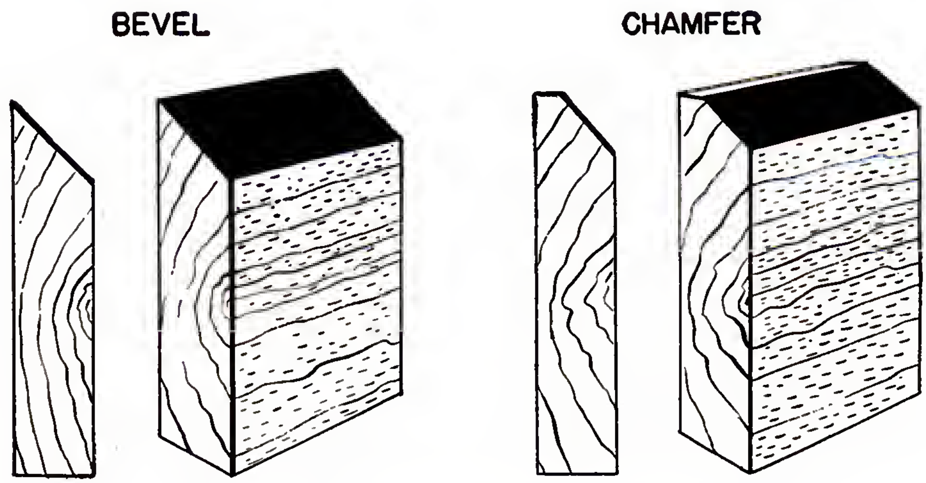


Figure 132.—Beveled and chamfered edges.

ers. The T-bevel is used to lay out and check EITHER beveled OR chamfered edges or ends.

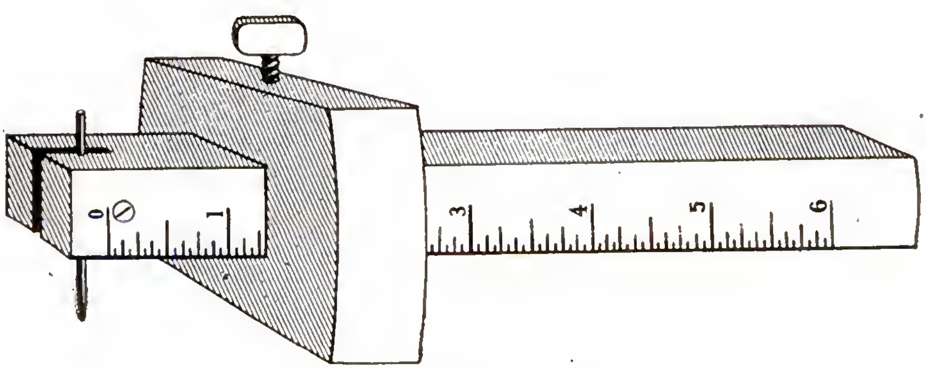


Figure 133.—The marking gage.

Woodworking layouts are usually marked off with a chisel-pointed pencil. Extremely accurate layouts, for cutting special joints, are made with a sharp knife-point. Lines parallel to edges and ends are quickly

marked with the MARKING GAGE, figure 133. Keep the spur point of the marking gage sharply pointed so you'll get a clean, fine line. This gage marks best when it's PUSHED with just enough pressure to make a distinct line. Keep the face of the gage head pressed snugly against the edge of the board, or the marked line will be "wobbly" and inaccurate.

Before you mark with the gage, check the measurement from the spur point to the head with a rule—the scale on the gage beam may be inaccurate.

HAND SAWS

The CROSS-CUT HAND SAW is the kind used for odd-job sawing around the home and shop. This saw is pictured in figure 134. Notice that the teeth have alternate "set," similar to the set of the hack saw blade. When a saw is properly set and filed, a needle will slide along the V-groove formed by the tooth points.

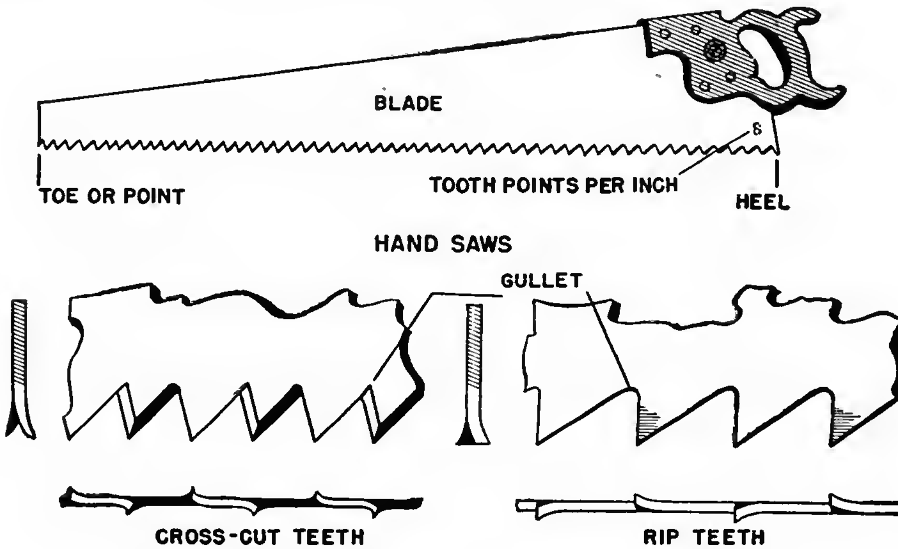


Figure 134.—Cross-cut saw; cross-cut and rip teeth.

The cross-cut saw works best for cutting "across the grain" of the wood. It can be used for ripping "with the grain" but its teeth soon clog up and cause

the saw to cut slowly. The hand RIP SAW, with its chisel-shaped teeth, is designed to cut with the grain. The teeth of the cross-cut are triangular, sharp points, but the rip teeth points are flat and straight, just like

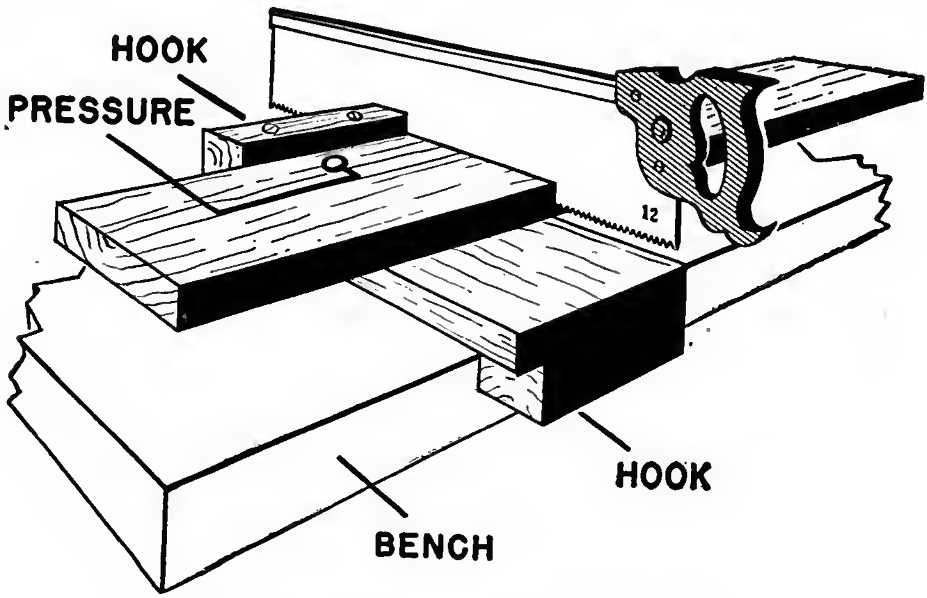


Figure 135.—Back saw and bench hook.

a row of chisels set at an angle. Learn to identify these saws quickly by the shape of the teeth, and by their appearance.

The size of a saw is determined by the length of the toothed edge and by the number of tooth points per inch. Rip saws are usually 26 inches long, and cross-cuts run from 20 to 26 inches long. Cross-cut hand saws usually have 8 to 11 points per inch, and rip saws 5 to 8 points per inch.

Accurate hand sawing, on small stock, is done with a BACKSAW. It's a special cross-cut saw with fine teeth (12 to 14 points per inch), and a stiff steel band reinforces the top edge. Use the bench hook, shown in figure 135, to help you hold the stock firmly and solidly. The MITER BOX is a special frame used with a 30 or 36 inch backsaw. It's your best bet for cutting angles accurately and easily.

Compass and keyhole saws are designed to make cuts for holes and slots that cannot be bored with a brace and bit. Use a bored hole, with a diameter

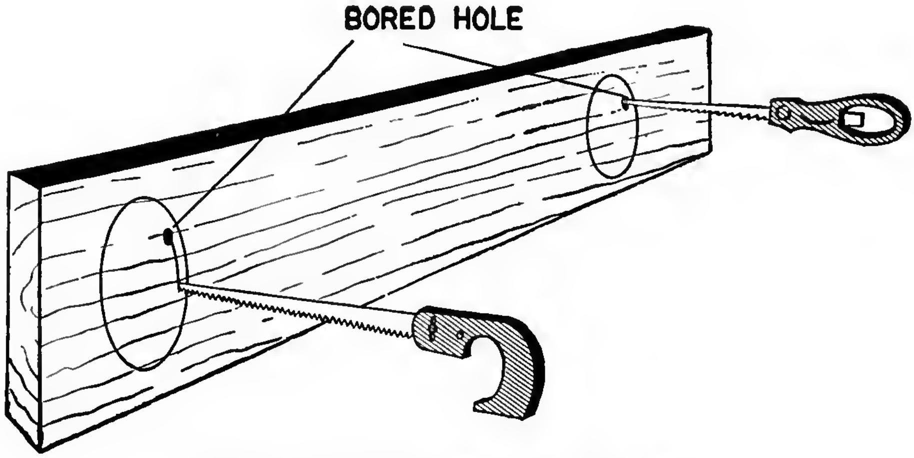


Figure 136.—Compass and keyhole saws.

greater than the saw width, to allow the saw to begin the cut. The teeth resemble those of the cross-cut saw.

USING HAND SAWS

Secure your stock (that's the board) so that it's held rigidly in the vise, or on the bench top with clamps. A wide-top saw horse serves well when sawing large boards, especially when you're using the rip saw. You'll have a layout line to guide your saw cut—STAY JUST OUTSIDE THAT LINE. Leave room for smoothing and truing the cut surface later.

Start a CROSS-CUT saw with a light backward PULL; but begin a RIP cut with a gentle PUSH. Hold the saw handle with one hand and use the RAISED THUMB of the other hand to guide the saw blade as the cut is started. Be sure to keep that thumb HIGH so the teeth won't jump the track and "hash-mark" your hand.

After the cut is started, cut with long, free and easy strokes. Apply medium pressure on the forward stroke and NO pressure on the backward stroke. Avoid

excessive pressure and speed so you won't jam or kink the saw. And be careful not to cant (lean) the saw to one side. If the saw tends to stick in the kerf (cut), you can wedge the open end with a screwdriver or a wooden wedge. The saw may stick because its teeth

Figure 137.—Hold your thumb high to start the saw.

need to be filed and set. Saws are EASY to set with a SAW SET. Get a carpenter's mate to start you off, then finish

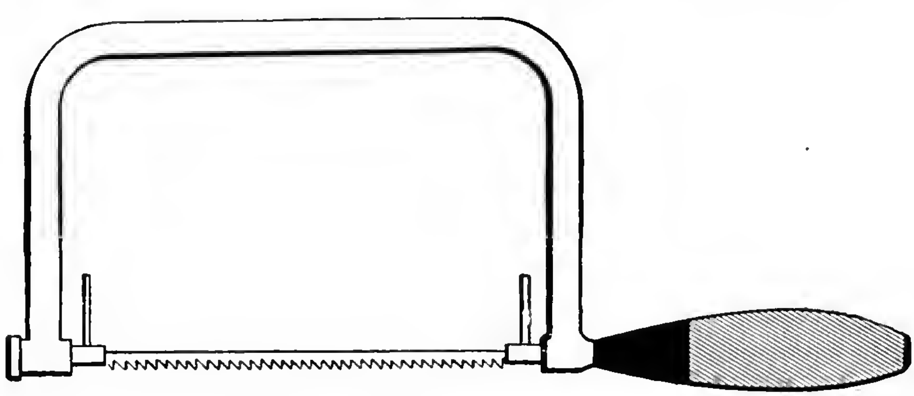


Figure 138.—Coping saw.

the "setting" by yourself. Filing saw teeth by hand is NOT easy for a beginner. Get some expert help before you tackle that job.

As you near the end of a cut, ease up on the pressure to avoid splitting the wood and losing control of the saw. And don't saw into bench tops, saw horses, or boards containing nails.

Now we come to the exception that proves the rule —the COPING SAW. It is PULLED through the wood and its teeth point TOWARD THE HANDLE. Be sure you pull it or you'll kink or break the blade. For ordinary cutting keep the coping saw blade PERPENDICULAR to the face of the board.

PLANES

You may be lucky enough to have power planers, surfacers, and jointers to smooth and true board stock, but for many jobs you'll need some type of hand plane.

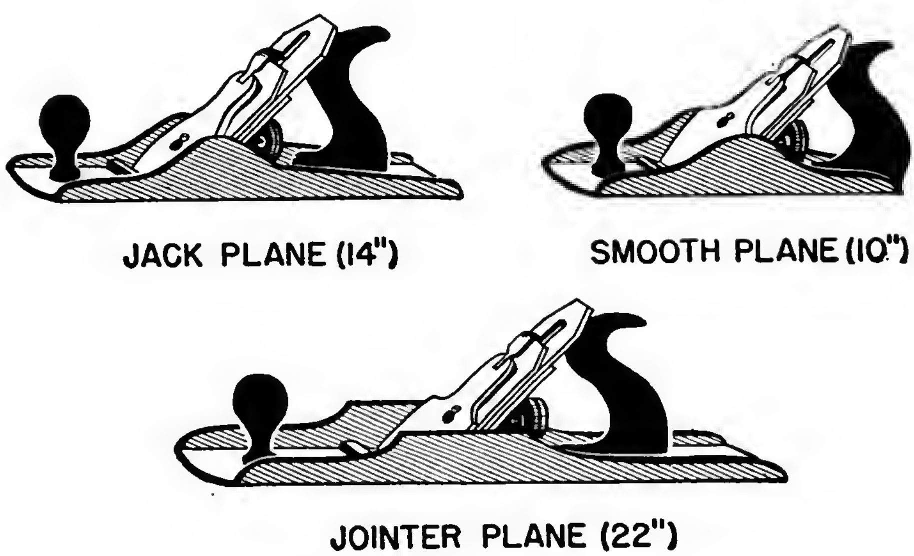


Figure 139.—Types of planes.

For smoothing rough surfaces and planing boards to size and squareness, you'll use the JACK PLANE. It's your "jack of all trades" plane, and is useful for a variety of purposes. The bed of a jack plane is made of cast iron or aluminum, and is about 2½ inches wide and 14 inches long.

The SMOOTH PLANE is similar to the jack plane, but is only 9 or 10 inches long. It's used for fine work on small pieces of stock. The FORE PLANE also resembles the jack plane but is wider and about 18 inches long.

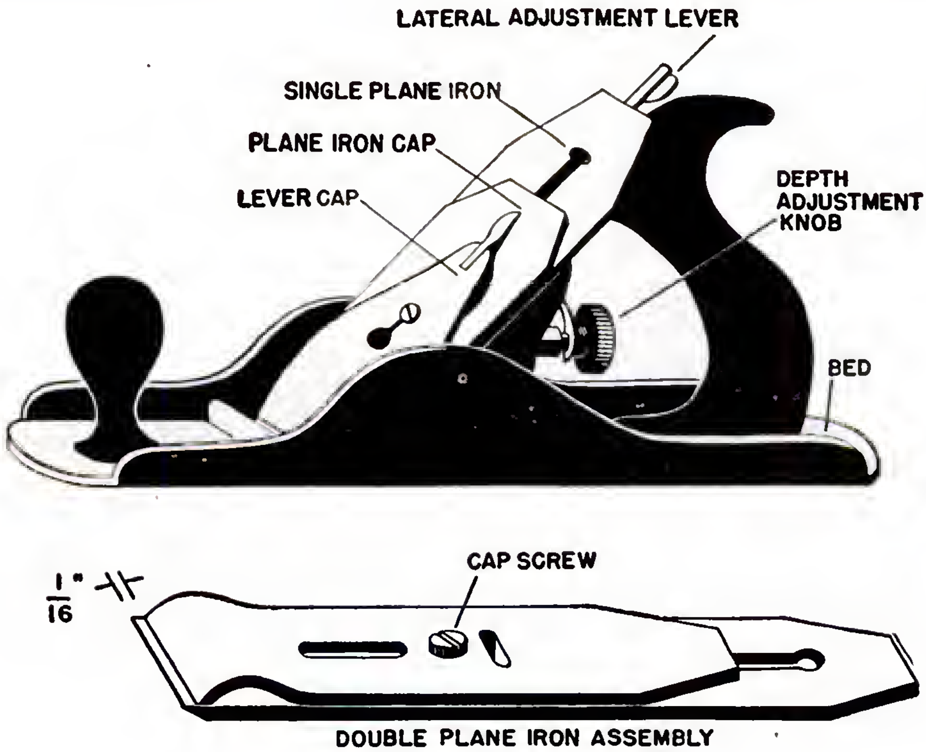


Figure 140.—Jack plane adjustment.

Use it and the JOINTER PLANE (22 to 30 inches long) for truing the edges of long boards. When you learn to use, adjust, and sharpen any one of these planes you won't have any trouble handling the others.

The cutting part of the plane is referred to as the DOUBLE PLANE IRON. It consists of a single PLANE IRON and a plane iron CAP, with a cap screw to hold them together. This double plane iron assembly is held tightly in the plane bed by a spring type LEVER CAP. It's all shown in figure 140.

If the plane cuts too much, or not enough, adjust the depth of cut with the DEPTH ADJUSTMENT KNOB, which is located in front of the handle. If the cutting edge

removes more wood on one side than on the other, adjust the double plane iron sidewise with the LATERAL ADJUSTING LEVER.

SHARPENING THE PLANE IRON

You can't do a good job with a dull plane. If the edge is just slightly dull, and has no deep nicks, a little careful honing on an oilstone will restore the keen edge. Here's how you do it—

Hold the single plane iron on the oil stone in the position shown in figure 141. Then move it back and forth with downward pressure. Maintain the same angle all the time to avoid rounding the edge. After 12 or 15 strokes, turn the iron over and hone it FLAT on the stone for a few strokes.

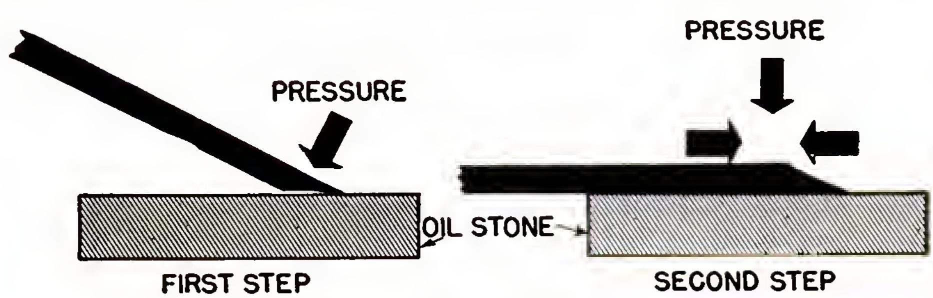


Figure 141.—Honing the plane iron.

Continue honing first one side and then the other until the edge is sharp enough to shave the hair off your wrist. If it will do that, brother, it will cut wood with the greatest of ease.

If the cutting edge is in bad shape and has deep nicks you'll have to regrind the edge. The grinding method is illustrated in figure 142*A*. The finished grinding job should be like view *B*. Don't leave the edge looking like the one in view *C*. Check the squareness of the edge with a try-square, and the bevel angle with a T-bevel or bevel protractor.

As you grind, slide the plane iron back and forth across the face of the revolving wheel, and dip it in

water frequently. This prevents burning the metal and drawing the temper. You may be able to grind a burned edge until it's sharp, but it WON'T STAY sharp in use.

After the grinding is done, the plane iron must be carefully honed to remove the rough "wire edge" and

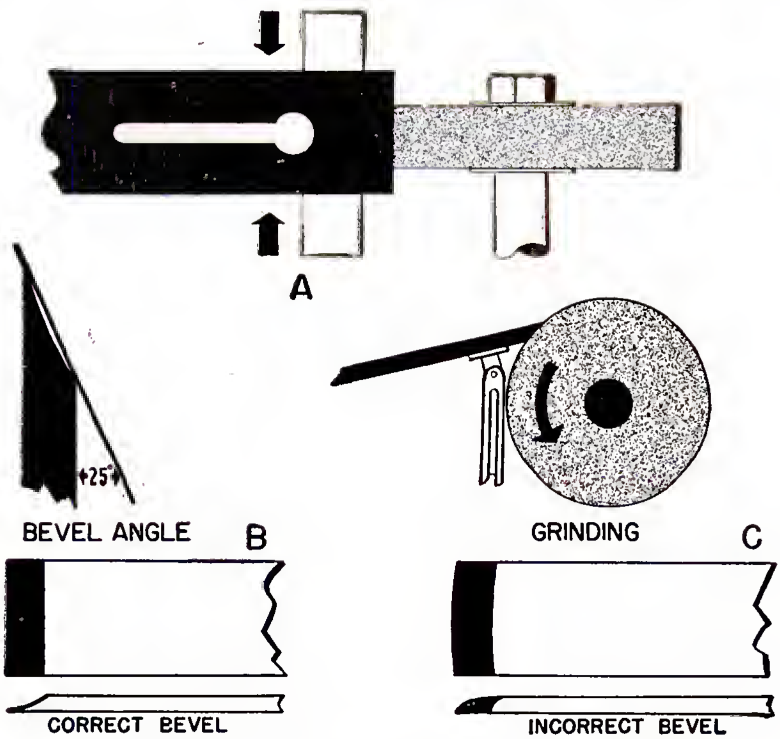


Figure 142.—Grinding the plane iron.

to secure a razor-sharp cutting edge. Then assemble the plane iron AS SHOWN in figure 140, and make a trial cut on scrap stock. Be sure the single plane iron and the plane iron cap are fastened together properly.

USING THE PLANE

Try to determine the general direction of the grain of the wood before you start to plane. PLANE WITH THE GRAIN—not against it. When you've decided in which direction to cut, clamp the stock securely in the vise or on the bench top. When stock is held in the

vise, protect it with pieces of scrap wood—otherwise the vise jaws will scar the surfaces.

Push the plane with steady, level strokes. Start the cut with extra pressure on the front of the plane bed. Push the plane the entire length of the stock, and finish the stroke with added pressure on the after part of the plane. This method, diagrammed in figure 143, prevents rounded corners.

Inexperienced workmen have a tendency to "jump" the plane at the stock with a quick vicious lunge—sort of a "hit-and-run" technique. You can spot these

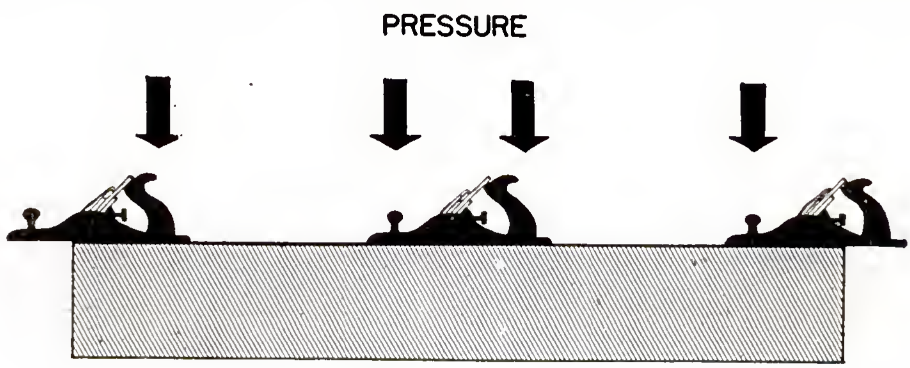


Figure 143.—Pressure Control.

greenhorns easily because they're the birds you hear say, "That plane is no good. It won't cut straight." Their excuse won't hold water, because a workman is supposed to keep his tools in good working condition. What those men lack is PRESSURE CONTROL, and the correct starting technique.

Here's a tip you can follow to make planing easier when you're taking a rough cut. SLANT the plane across the stock as you push it forward. This method allows the cutting edge of the plane to SLICE OFF the shavings. You probably use the same principle when you shave with a safety razor by holding it at an angle as you trim off your facial foliage. Figure 144 is the top view of a plane properly slanted for a slicing cut on rough stock.

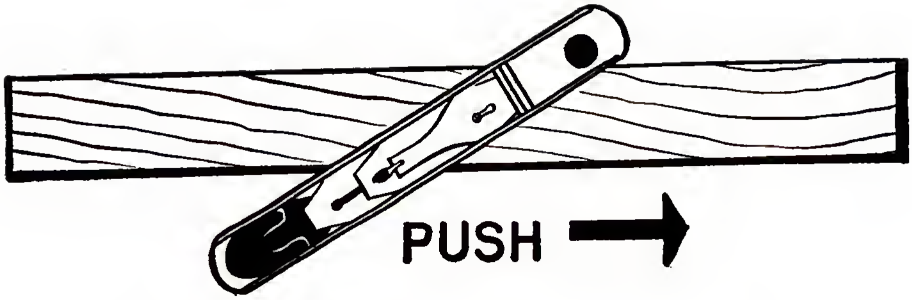


Figure 144.—Slanting the plane for rough cutting.

Use the fingers of your forward hand to guide the plane along. Just keep your thumb on top to exert downward pressure, and let the fingers slide under the plane to do the guiding. But before you guide with your fingers, be sure the surface of the stock is smooth! SPLINTERS are tricky, and they don't sound off with a warning signal.

When you plane the END GRAIN of a board, you can avoid trouble (splitting) by using one of the methods

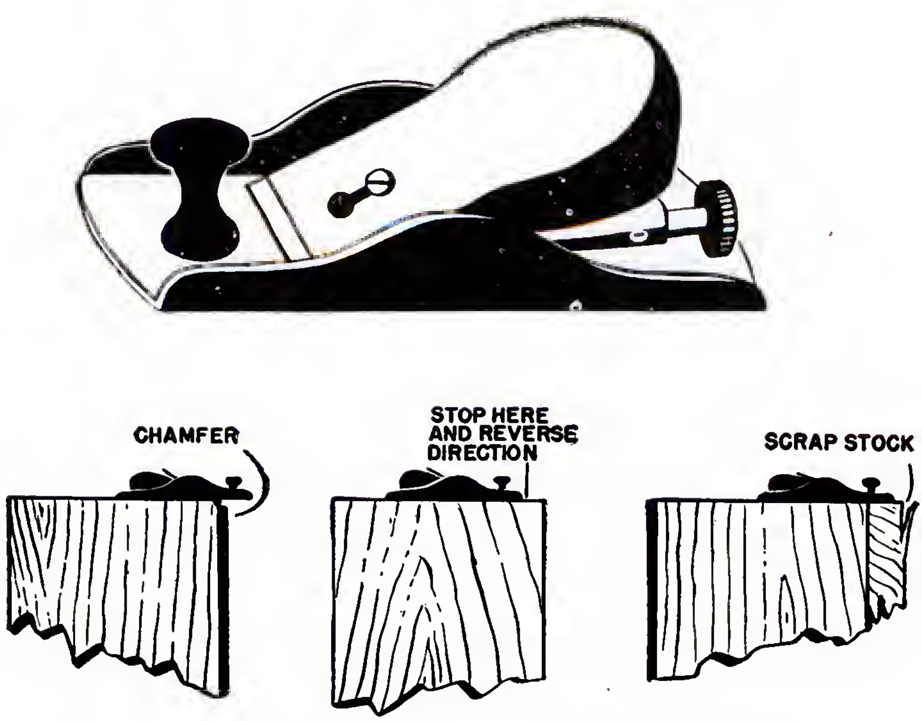


Figure 145.—Planing end grain with the block plane.

shown in figure 145. The jack plane or smooth plane may be used on end grain, but a BLOCK PLANE is better if one is available, because it is specially designed for cutting end grain. Its plane iron, or blade, is set at a very small angle with the bottom of the bed to aid it in cutting across the grain. The block plane is designed to be held in one hand, but it's OK to use both hands if you're careful.

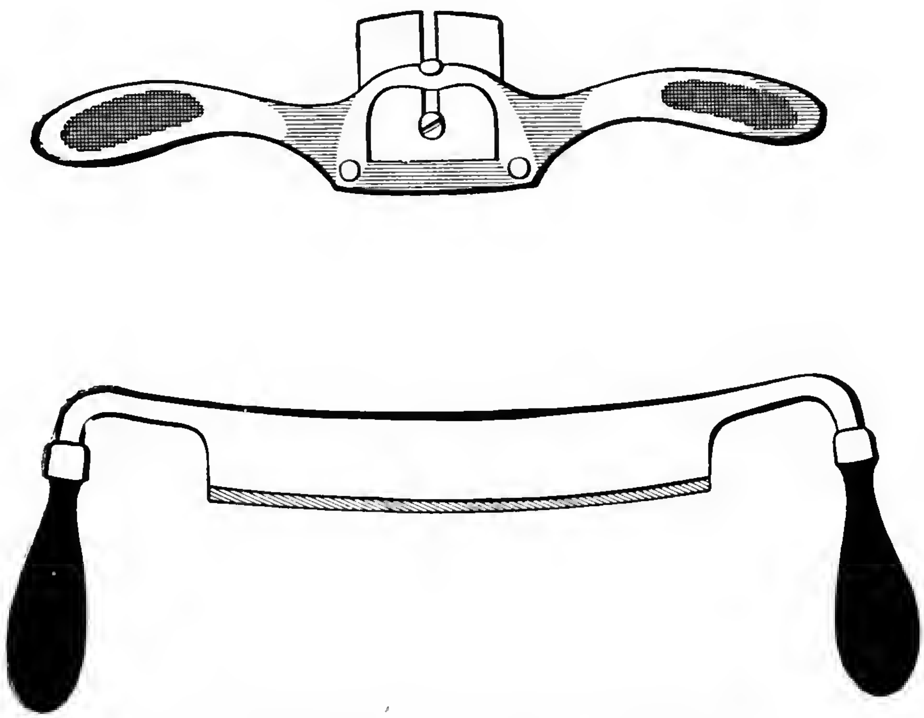


Figure 146.—Spokeshave (top) and Drawknife.

When you're through using a plane, adjust the plane iron so that the cutting edge does not stick out past the bottom of the bed, and when you lay a plane down, place it ON ITS SIDE TO protect the cutting edge. This will prevent dulling and nicking of the blade. Keep the metal parts oiled when the plane is not in use. And don't let the plane drop. It breaks easily at the throat, which is the slot through which the cutting edge protrudes.

For cutting irregular curves you will use the SPOKESHAVE or the DRAWKNIFE. The spokeshave works on the same principle as a plane, but has an extremely short bed. The drawknife is used for rough shaping work.

WOOD CHISELS

If you can't do a certain job with saw and plane, the wood chisel may be the proper tool. For heavy work a SOCKET CHISEL is used. Pound it with a mallet—NEVER with a hammer. For light work, use the TANG TYPE chisel. It is not pounded but is pushed with a paring or slicing motion. Push the chisel with one hand; guide and control it with the other. Both types

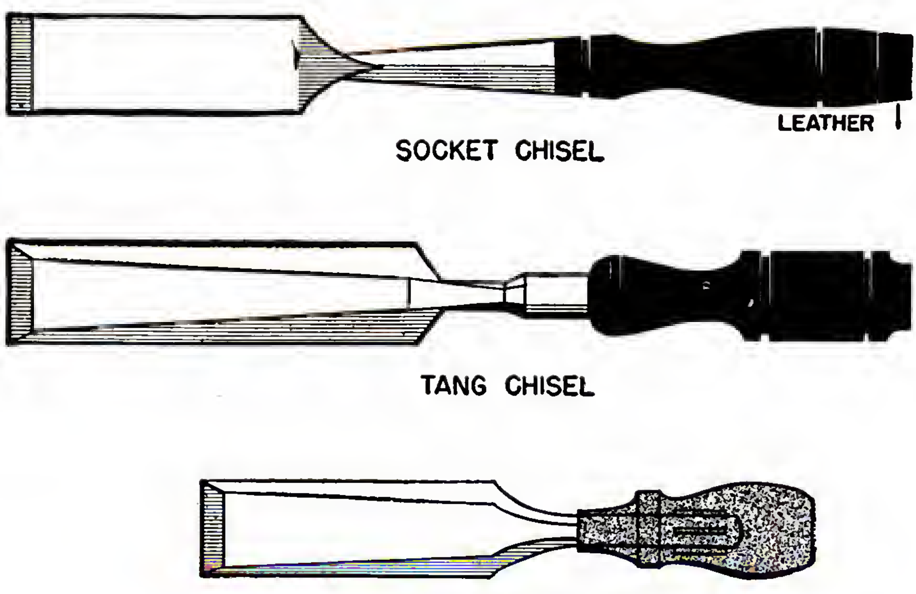


Figure 147.—Wood chisels.

of wood chisels are pictured in figure 147. The size of these tools is determined by the distance across the blade. For utility work (use outside the shop) you need a set of short socket chisels, containing the ⅛, ¼, ⅜, ½, ¾, and 1 inch sizes.

Chisels are used to cut and fit joints, "gain out" recesses for hinges, and to do other cutting jobs the saw and plane cannot handle. Some of these uses are depicted in figure 148.

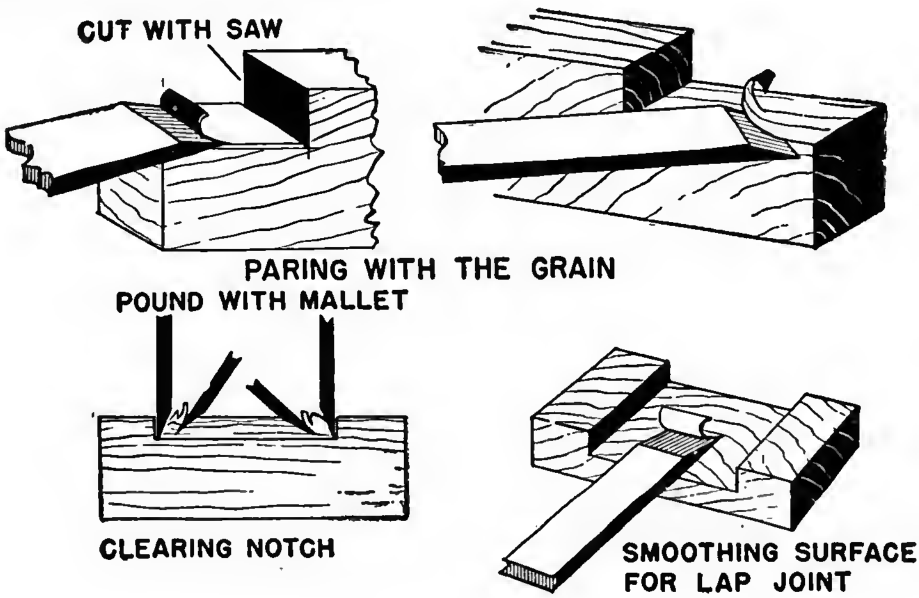


Figure 148.—Using the wood chisel.

The chisel works on the same principle as the plane, so be careful to cut WITH THE GRAIN of the wood. If you attempt to cut against the grain, the wood probably will split. Keep a razor edge on the chisel. You can grind and hone it by the same methods used for plane irons. Be especially careful not to burn the cutting edge.

The wood chisel sends more sailors to sick bay than any other woodworking tool. You won't cut yourself if you NEVER ALLOW ANY PART OF YOUR BODY TO GET IN FRONT OF THE CUTTING EDGE. Always clamp your work in a vise, or secure it in some manner that permits you to keep your hands and body BACK of the sharp cutting edge.

BRACES AND BITS

Holes in wood are usually bored with AUGER BITS. These bits are held and rotated by some type of brace.

The brace has a holding device, known as a CHUCK, which clamps the square shank of the bit. A RATCHET BRACE is shown with an auger bit in figure 149. The point of the bit does the cutting, so it's enlarged to show its important parts.

The LIPS and NIBS of the auger bit may be sharpened with a special auger bit file. It's made thin so you can file in the narrow space between the SPUR and nib. The file has safe edges to protect the parts that are not

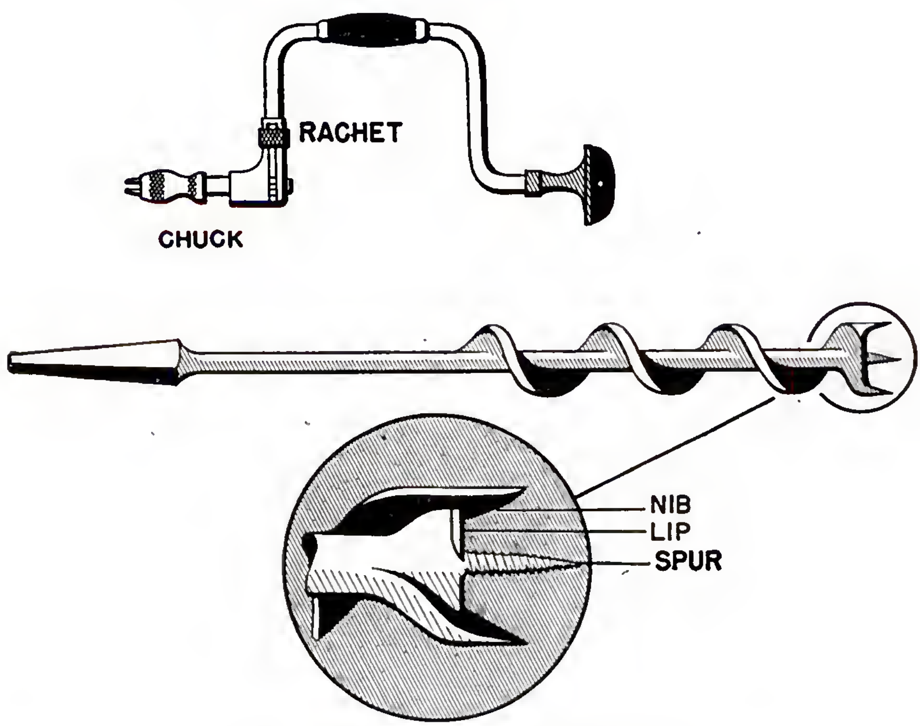


Figure 149.—Brace and auger bit.

filed. File only on the inside of nibs and lips.

The spur is a screw that pulls the bit into the wood. Don't use much pressure after the cut is started. Let the spur do the work. When you bore a hole COMPLETELY THROUGH a piece of wood, use the system shown in figure 150. This DOUBLE-BORING SYSTEM prevents splitting and tearing of the wood around the hole.

Auger bit sizes are stamped on the shank. If the number "6" appears on the shank, you'll know it's a bit that cuts a $\frac{6}{16}$ inch ($\frac{3}{8}$) diameter hole. A half-inch bit carries the number 8, indicating that the size is $\frac{8}{16}$

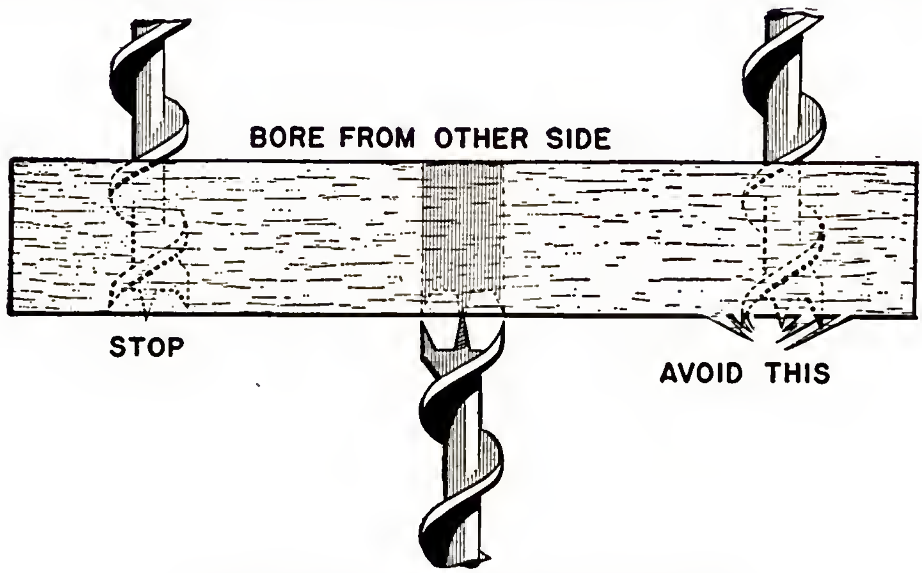


Figure 150.—Bore the hole from both sides.

or $\frac{1}{2}$ inch. Just remember that the number on the shank indicates the bit will bore a hole that many sixteenths of an inch in diameter.

Holes having a diameter under $\frac{3}{16}$ inch are usually made with a straight-shank twist drill, held in a hand drill or power drill. You learn about these tools in another chapter. You may have an AUTOMATIC push drill, such as that in figure 151, with a set of special straight-fluted bits.

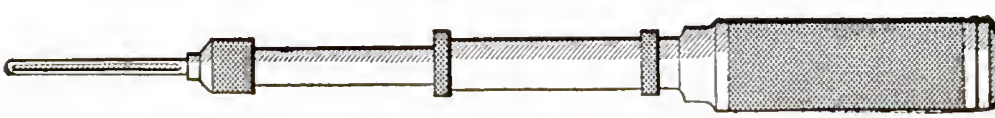


Figure 151.—Automatic push drill.

When you fasten wood pieces together with screws and when you use screws to secure hinges, hasps, locks, and braces to wood, you should drill small starting holes first. These small holes are called ANCHOR

HOLES and PILOT HOLES. Their use is explained by figure 152. Anchor holes should be about HALF the diameter of the screw shank. Pilot holes should be the SAME diameter as the screw shank, or slightly larger. The chamfered recess for a flat head screw is made with the COUNTERSINK.

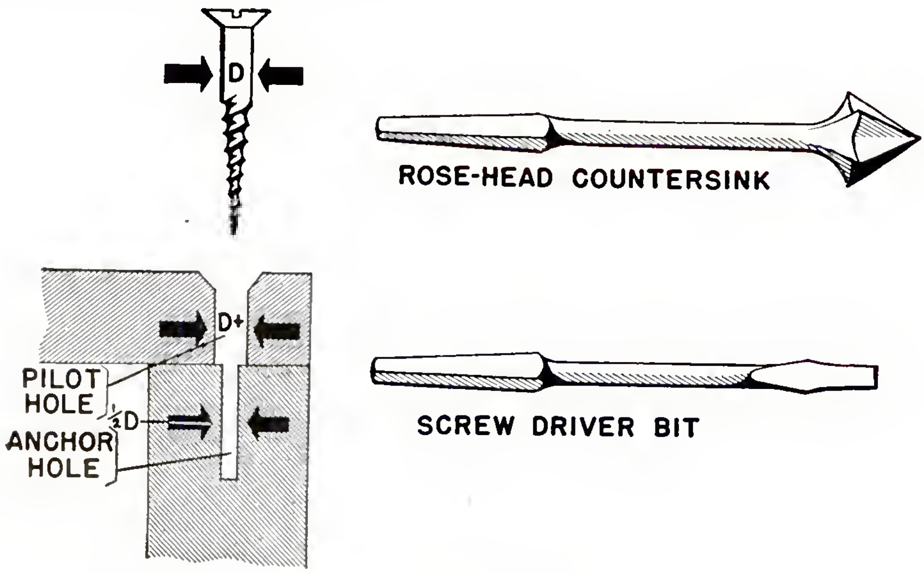


Figure 152.—Fastening with screws.

WOOD SCREWS

Common wood screws are usually one of two types, F.H.B. (Flat Head, Bright) or R.H.B. (Round Head, Blued). Screw heads may have the old-type single slot, or the new Phillips four-way slot. Screws for marine use are made of brass or stainless steel. They may be made of common steel and plated with cadmium, brass, or chromium. Ordinary steel screws rust away rapidly when exposed to salt water.

OVAL-HEAD SCREWS are often used to hold hinges and other hardware. LAG SCREWS have square heads which are tightened with a wrench, and are used to secure benches and machines to wooden decks. Sometimes lag screws equipped with expanding sleeves are used in concrete.

Avoid driving screws too tightly—you may strip the threads in the wood or twist the screw in two. Screw head slots burr easily, so use a screwdriver that won't slip. DON'T RUN YOUR THUMB OR FINGER OVER A SCREW HEAD. Small, almost invisible burrs may stick into your skin or cause bad cuts.

The SIZE OF SCREWS is determined by LENGTH and GAGE. The length of a flat-head screw is its TOTAL length, but the length of a round-head screw is meas-

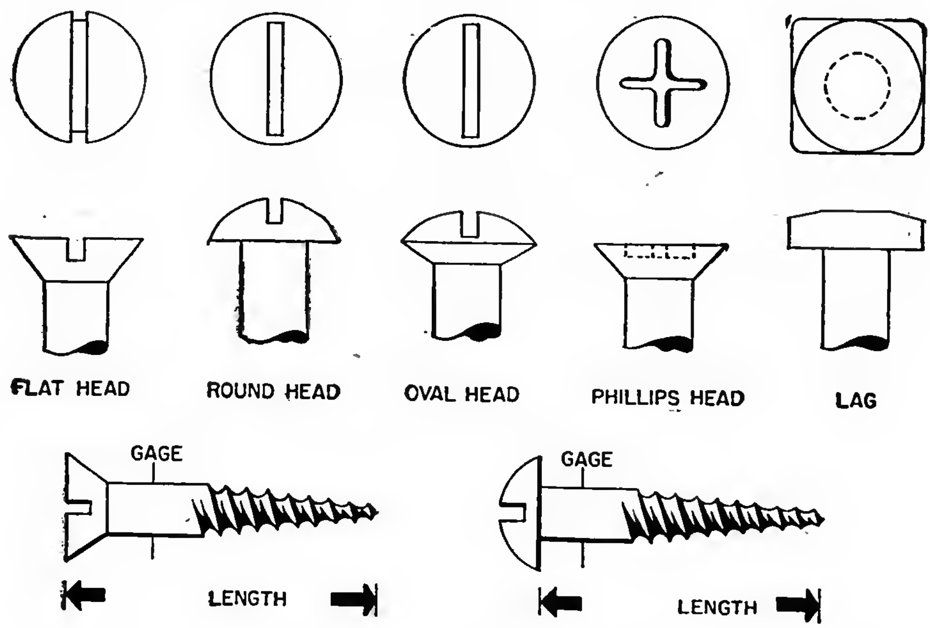


Figure 153.—Wood screws.

ured from the tip of the screw to the SHOULDER of the head. The gages range from No. 0 ($\frac{1}{16}$-inch diameter) to No. 24 ($\frac{3}{8}$-inch diameter). Commonly used sizes include $\frac{3}{4}$-inch-No. 7 for hinges, $1\frac{1}{4}$ inch-No. 9 for fastening two $\frac{3}{4}$-inch boards together, and 2-inch-No. 14 for heavy work.

Screws are furnished in boxes of one gross (144). The box label shows the length, gage, head shape, and kind of material from which the screw was made. Don't go to the storeroom with your fingers held out

and say, "I need some screws about this wide and this long." You'll have trouble getting the screw you need if you can't furnish more information than that. Your fellow workmen will respect you a lot more if you KNOW the correct names and sizes of tools and supplies.

MISCELLANEOUS WOODWORKING TOOLS

In practically all wood work you need a VISE in which to clamp your stock. The rapid-acting vise, figure 154, will save you a lot of time, but it is not as rugged as a continuous-screw vise. Regardless of the type of vise you use, you should face the inside of the vise jaws with wood to protect your stock.

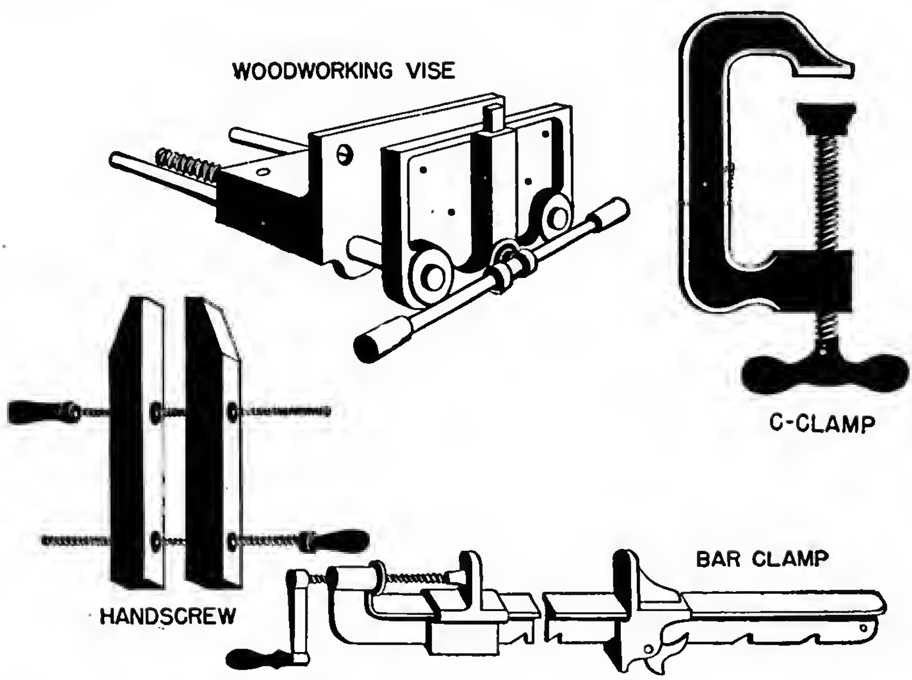


Figure 154.—Woodworking vise and clamps.

When you can't hold the stock in a vise because of its size or shape, you may be able to hold it with CLAMPS. The HANDSCREW should be used on wood only, because its wooden jaws will be damaged if it's used on metal. The C-CLAMP may be used for holding

any kind of stock. BAR CLAMPS are designed for clamping boards that have been glued edge-to-edge, and for clamping glued assemblies. Avoid unnecessary strain on clamps and vises. They are easily warped or sprung, and may break if too much force is applied.

The GOUGE is a chisel-like cutting tool, used to shape curved inside surfaces and to cut grooves and flutes. Its blade has a curved cross-section. The bevel, back from the cutting edge, may be either on the outside or inside. Patternmakers use gouges to carve fillets and other curved portions of wood patterns. The use and care of the gouge is about the same as for the chisel.

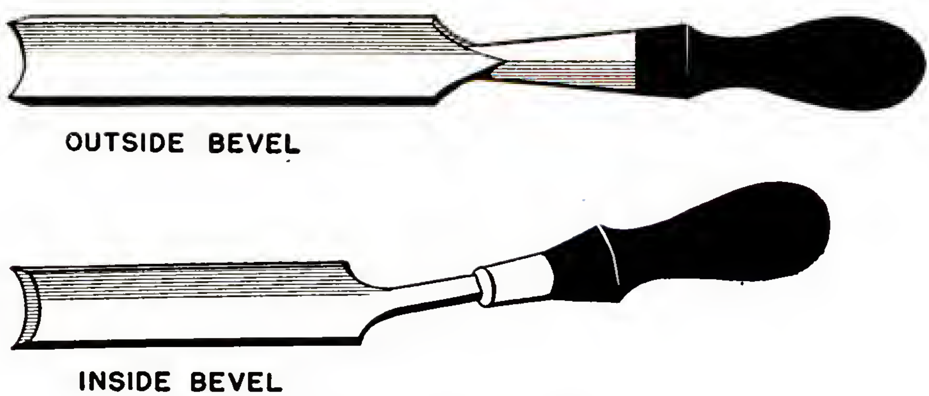


Figure 155.—Gouges.

RASPS and WOOD FILES are for smoothing irregular surfaces. Rasps have very coarse teeth and are made for rough work. Wood files, also known as CABINET FILES, are obtainable in several shapes, lengths, and tooth grades. They are used for smoothing wood much as other files are used on metal.

For smoothing flat surfaces your best bet is the SCRAPER. It's just a thin sheet of saw steel about 3 inches wide and 5 inches long. For scraping small areas you can hold the blade in your hands and push it along the surface. A two-handled holder is used for scraping large areas. Use the scraper just after planing and just before sandpapering. Scrape with the

grain of the wood and use long steady strokes. To sharpen the tool, place it in a vise and drawfile the edge you want to use. The filing leaves a burr or "wire edge" that does the cutting.

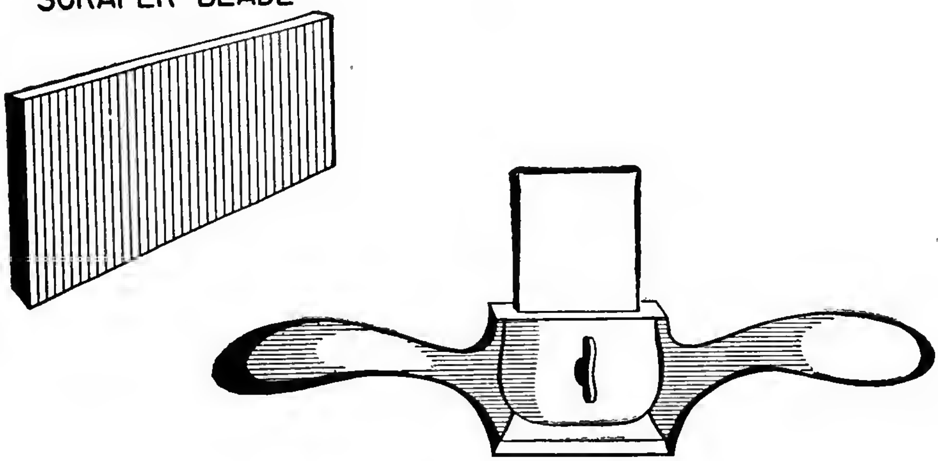


Figure 156.—Wood scraper.

Walls, foundations, and floors must be true and level. You can check on these factors by using a SPIRIT LEVEL and PLUMB BOB. When you were a small boy

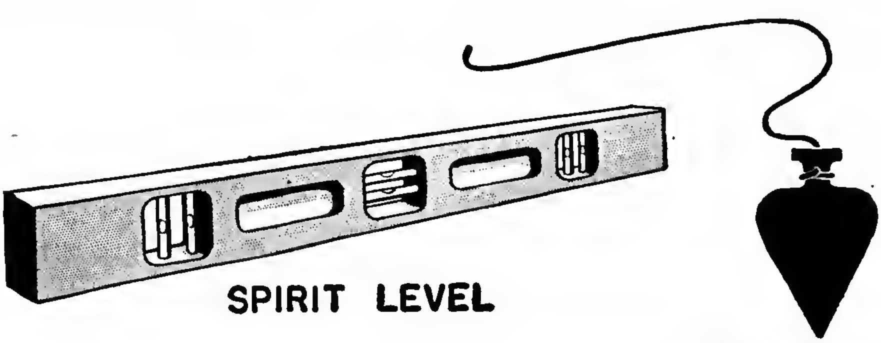


Figure 157.—Spirit level and plumb bob.

you probably watched carpenters use these tools on the framework of new houses. Plumb bobs are rugged. Levels are not, so avoid dropping them and be careful to set them in safe places when they're not in use.

You'll drive nails and brads with a NAIL HAMMER—sometimes called a claw hammer. The standard nail-hammer head weighs 16 ounces, but there are other weights. When you use a hammer, hold it at the end of the handle—don't choke it by holding it by the throat near the head. Use the same "hand-shake" grip recommended for using the ball-peen hammer. The FACE of the hammer head must be kept smooth

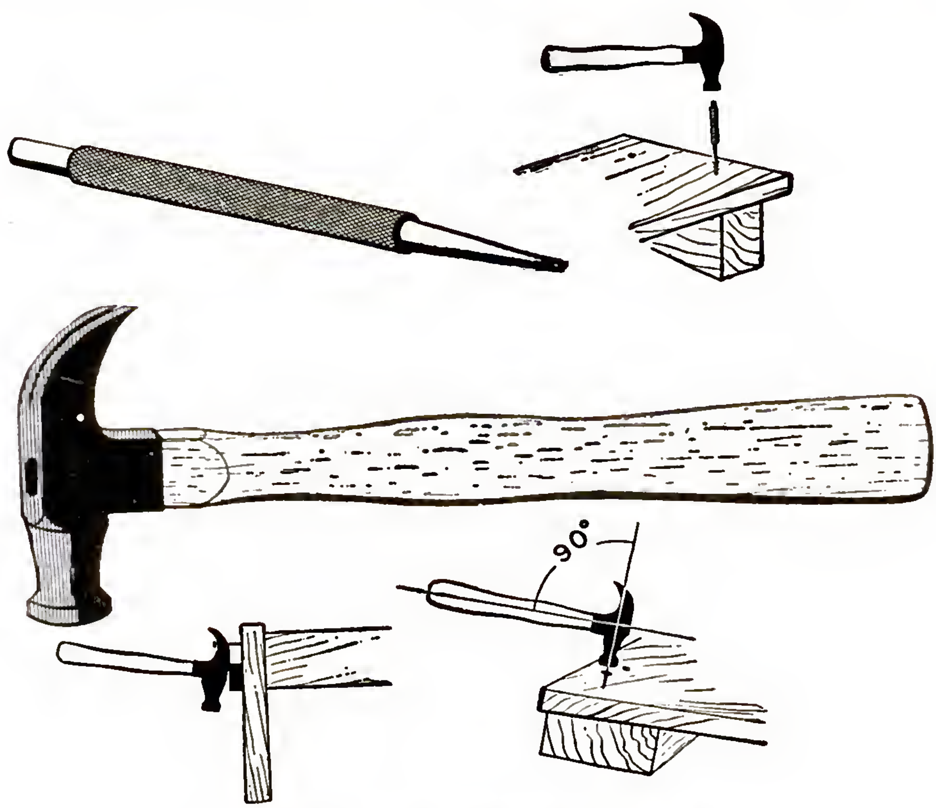


Figure 158.—Nail hammer and nail set.

and true or it will slide off nail heads and cause the nails to bend. DON'T USE A NAIL HAMMER TO WORK METAL, TO POUND COLD CHISELS, OR TO DRIVE RIVETS. Use it ONLY to drive nails and brads.

When you drive brads, and other small-headed nails, drive them so that the heads stop 1/8 to 1/16 inch from the surface. Then drive the heads flush or below the surface with a NAIL SET. Avoid leaving hammer

marks on the surface of the wood, no matter what kind of nails you're driving. Hammer dents are the "footprints" of sloppy workmen.

NAILS

COMMON NAILS and CUT NAILS are used for general construction work. FINISHING NAILS are used when it's desirable to sink the head below the surface. CASING NAILS are so-called because they are used to fasten

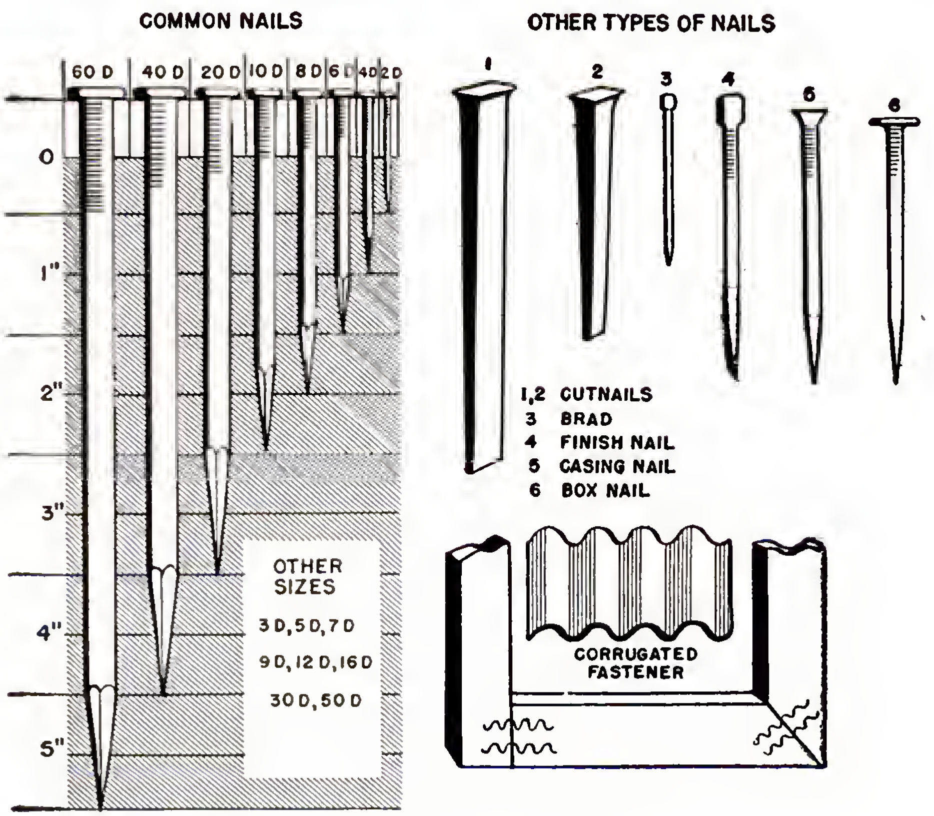


Figure 159.—Nails and nail sizes.

door and window casings. You'll use the smaller BRADS and WIRE NAILS for nailing plywood and other thin boards. Larger wire nails are used on crates. CORRUGATED FASTENERS, often called "wiggle nails," are used on frames. Commonly used nails and their sizes are pictured in figure 159.

HERE ARE SOME NAILING POINTERS—

Stagger rows of nails so they won't be lined up with the grain of the wood and cause splitting.

When you drive nails, drive them at an angle or slant—they'll hold better.

When you clinch nails, drive the points across the grain.

If the wood splits easily, drill a hole for each nail. Make the hole slightly smaller than the diameter of the nail.

HINGES

Cabinets, lockers, and chests require hinges for

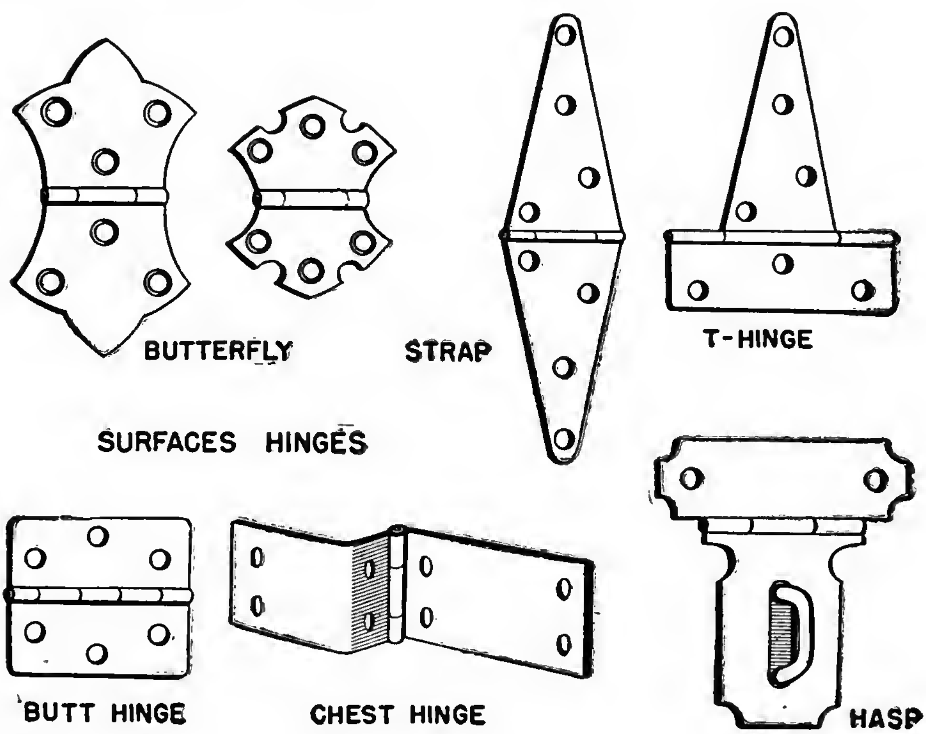


Figure 160.—Hinges.

doors and lids. The commonly used hinges are shown in figure 160. BUTT HINGES are "gained" into the wood so that only the pin part shows when the door is

closed. SURFACE HINGES are screwed on the outside of the door with the pin directly over the crack. The offset CHEST HINGE is best and strongest for sea chests and boxes. The HASP provides a way to secure doors and lids with a padlock.

If you use hinges on metal, don't try to fasten them with wood screws. Use sheet metal screws, bolts, or rivets. You may even want to weld or braze them on heavy jobs.

WOOD GLUE

Wood joints are glued together where it's difficult or impractical to use screws, nails, or bolts. The Navy usually supplies one pound cans of WATERPROOF CASEIN GLUE for general use, but you may use some of the new type resin glues. These glues are in powder form. They are easy to mix and use if you follow the manufacturer's directions.

You may use some of the old-type animal glue. It has to be heated, but it should NEVER be allowed to boil. It's not waterproof.

Don't expect any glue to hold unless the wood parts fit CLOSELY. Glue has very little strength of itself, but it makes a permanent joint IF the parts fit. Glued pieces should be held under pressure with clamps or weights until the glue is thoroughly dry or "set." For best results leave glued boards under pressure for twenty-four hours.

used for making long measurements. These two kinds of rules must be kept exceptionally clean and dry. Any

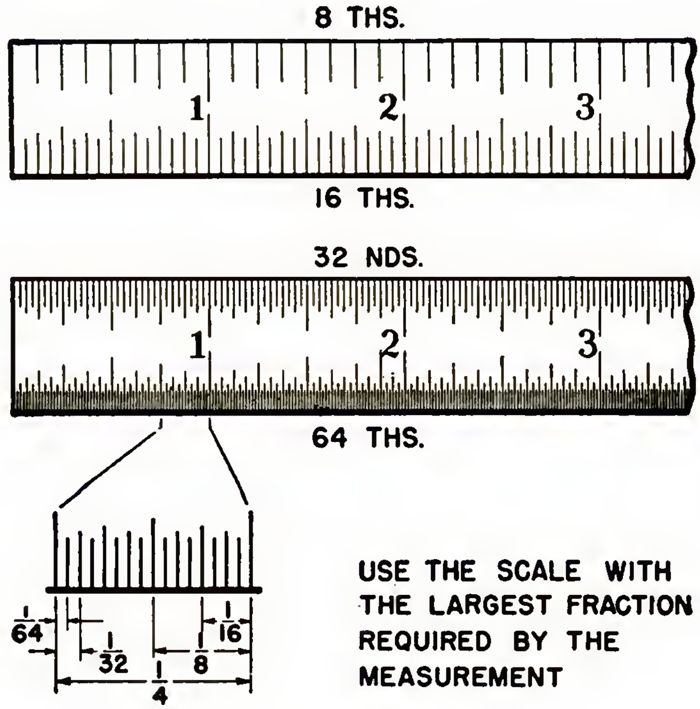


Figure 161.—Steel rule.

dirt or sand on them tends to wear away the marks and rust the steel.

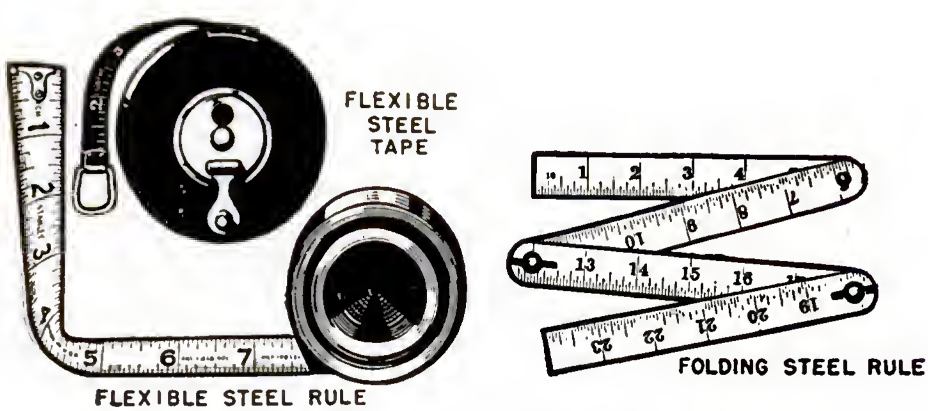


Figure 162.—Other steel rules.

A DEPTH RULE has a narrow blade which slides through a slotted locking arrangement. It is used to

measure the depth of holes, slots, keyways, and other recesses. Some of these rules have protractor heads and can be used for measuring angles as well as the depth of holes drilled at an angle to the surface.

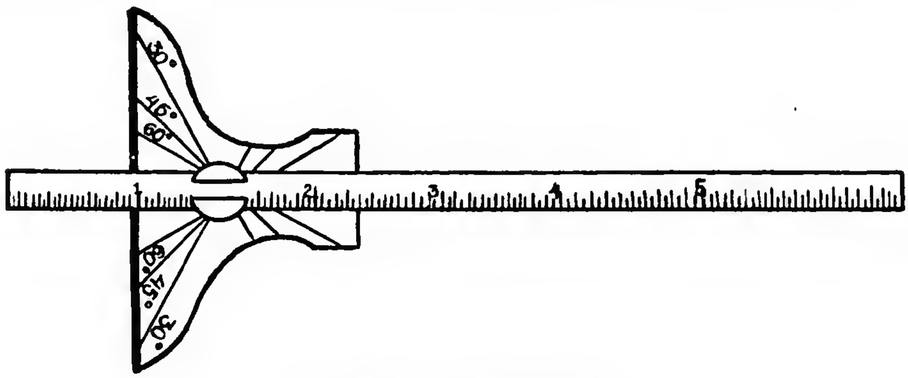


Figure 163.—Depth rule.

The HOOK RULE, figure 164, is convenient to use when you're measuring from an edge—especially an edge that is out of sight. Ordinarily it's a bad prac-

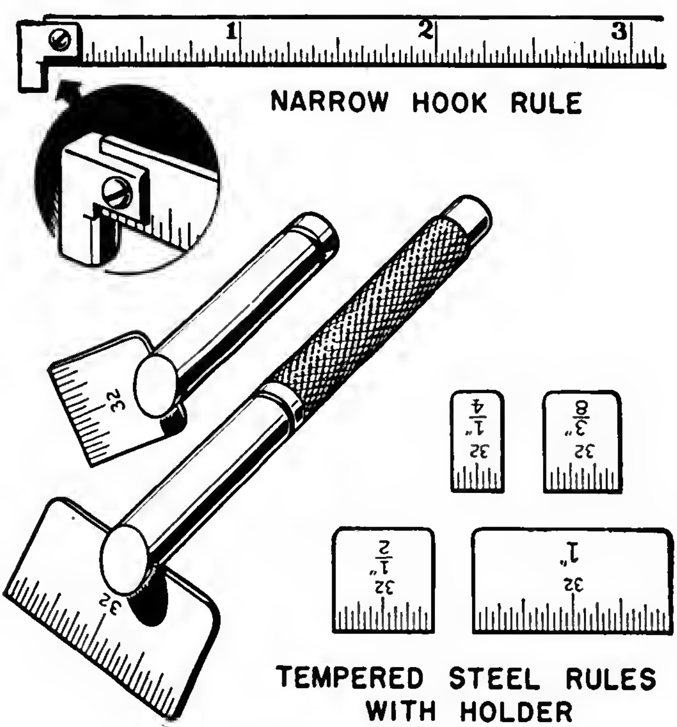


Figure 164.—Hook rule and narrow rules.

tice to measure from the end of a rule, but it's permitted with the hook rule and the flexible rule.

The narrow rules, called "tempered steel rules" in figure 164, are used in spots that other rules cannot reach. A number of small rule sections are provided as a set, together with a long-handled holder.

OUTSIDE CALIPER rules are used to measure the outside diameters of rods, shafts, bolts, rivets, etc.; and to measure width, thickness, and length within the capacity of their jaws. INSIDE CALIPER rules are used to take measurements of slots, grooves, and openings.

The caliper rule shown in figure 165 has jaws de-

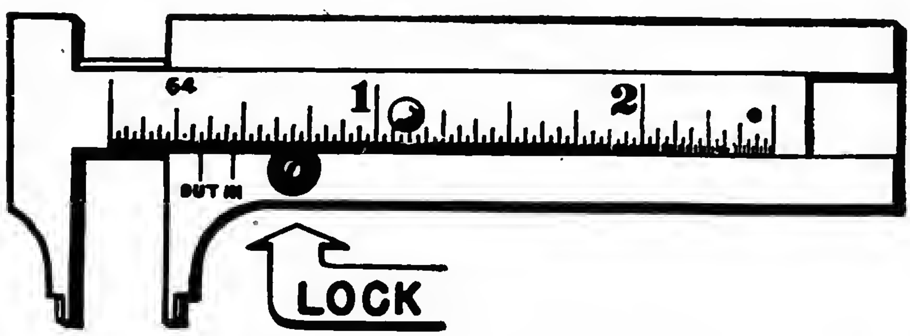


Figure 165.—Combination caliper rule.

signed to make EITHER inside or outside measurements. If you're measuring the diameter of a HOLE, you read the scale mark that lines up with the mark labeled IN. When you measure the diameter of a SHAFT you read to the OUT mark.

CALIPERS

Calipers are used in the same manner as caliper rules, but they have no scale. The "set" of calipers must be measured with a rule, square, caliper rule, or micrometer. Calipers are made in enough shapes and sizes to handle any job.

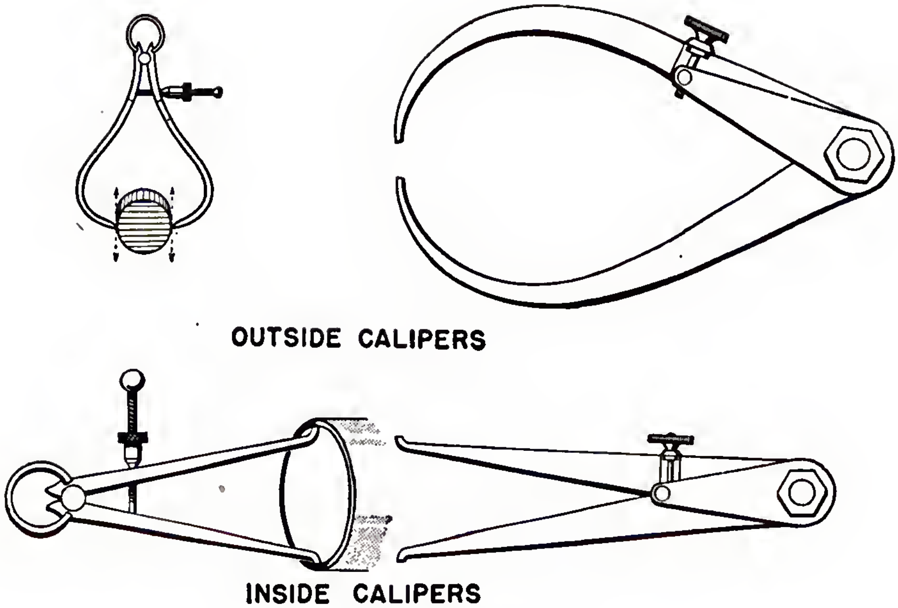


Figure 166.—Calipers.

Calipers are commonly made with a screw-and-nut adjustment, which puts tension on a spring to hold the setting desired. Other calipers are of the FIRM-JOINT, friction-holding type. This type of caliper has thin flat legs, and is excellent for measuring in narrow spaces.

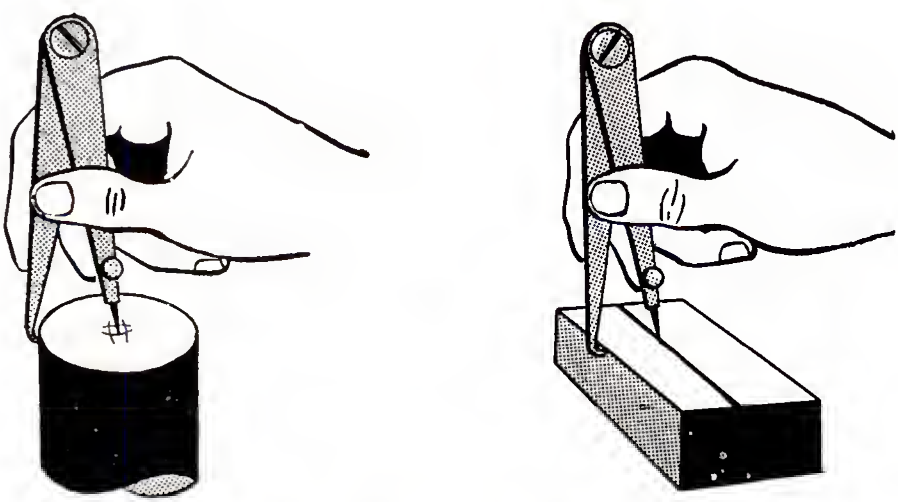


Figure 167.—Hermaphrodite calipers in use.

HERMAPHRODITE CALIPERS, pictured in figure 167,

are half caliper and half divider. They are used to measure and mark from an edge. The setting of the tool must be taken from a rule. You can use this caliper to mark parallel lines, locate centers for drilled holes, and to find the centers of pieces of round stock.

SQUARES FOR ANGLES

Squares are sometimes used for making measurements, but you'll use them most when you're laying

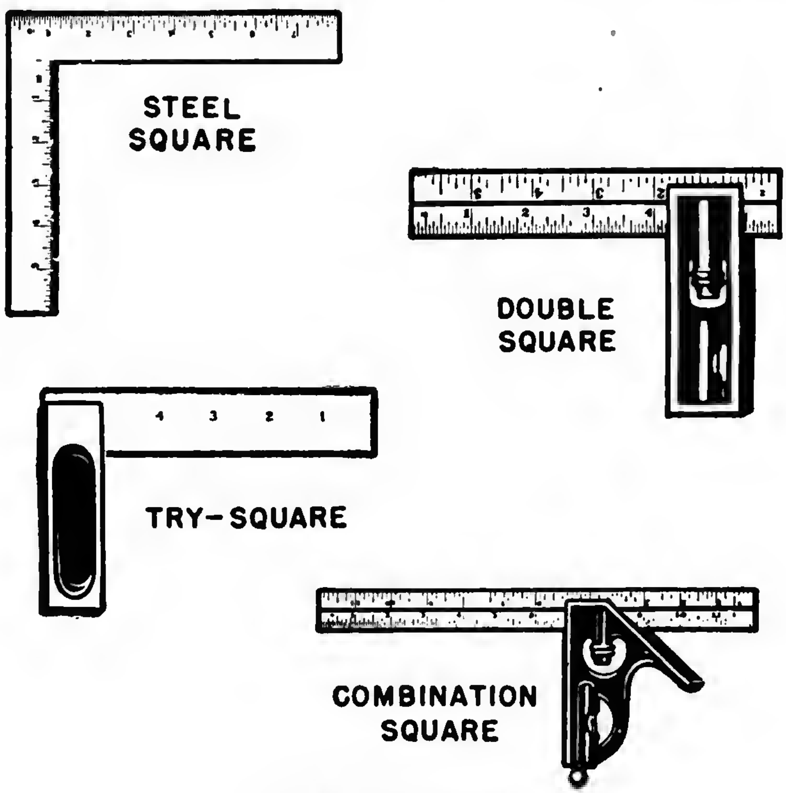


Figure 168.—Squares.

out and checking angles. The STEEL SQUARE, TRY SQUARE, and DOUBLE SQUARE are all designed to check right angles (90 degrees). Squares must be handled carefully or they won't STAY square. A square that isn't true is worthless.

COMBINATION SQUARE SETS are designed to handle the measurement, layout, and checking of angles other

than 90 degrees. One of these sets has a 10- or 12-inch BLADE (rule), and three heads that may be used with it. The SQUARE STOCK may be used as a regular square for 90-degree angles, or as a square for 45-degree angles. It also has a built-in SPIRIT LEVEL which may be used for leveling horizontal surfaces and plumbing vertical surfaces. The CENTER HEAD is used with the blade for marking the centers of round objects. Two intersecting lines are marked to establish a center. The PROTRACTOR HEAD is used with the blade to measure ANY ANGLE. It has a circular scale marked off in degrees, and the blade may be SET and LOCKED at any desired angle.

MICROMETERS FOR PRECISION

You should be able to make a measurement with a rule that will be accurate within ± .005 inch. That's good enough for some jobs, but it's NOT accurate enough for real PRECISION WORK. When a measurement must be "right on the nose" you'll reach for the MICROMETER—or "mike," if you like its shorter name.

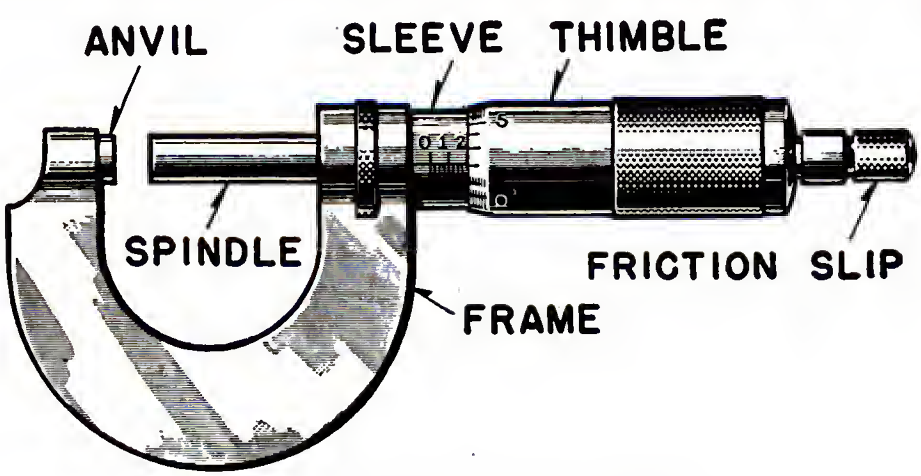


Figure 169.—1-inch outside micrometer.

The mike you'll probably use first is the one-inch micrometer shown in figure 169. It's designed for making outside measurements not over one inch in

thickness or diameter. Larger mikes are made to handle the jobs that are beyond the capacity of the one-inch mike. They all work on the same principle, and are used and read in the same manner.

The SPINDLE of a mike, shown in figure 169, is THREADED through the SLEEVE and fastened to the THIMBLE. The standard spindle has 40 threads per inch, so it moves $\frac{1}{40}$ of one inch for each revolution of the thimble. $\frac{1}{40}$ of an inch is the same as 25 thousandths of an inch. (.025). The THIMBLE SCALE is

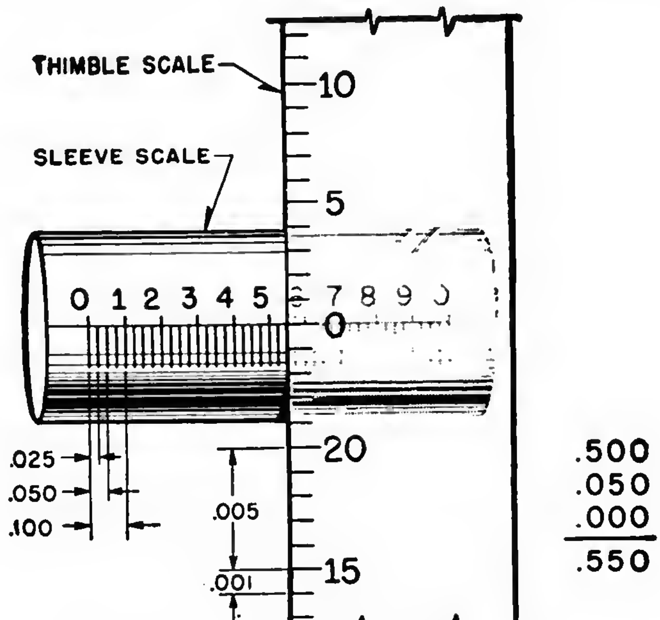


Figure 170.—1-inch micrometer scale.

marked off into 25 spaces, with each space representing ONE THOUSANDTH of an inch (.001).

Now take a look at the SLEEVE SCALE, figure 170. Each small space on the sleeve scale represents 25 thousandths of an inch. (.025); and one revolution of the THIMBLE moves the spindle the distance of one space on the sleeve scale. The numbers ABOVE the sleeve scale mark divisions of $\frac{1}{10}$ of an inch. (.100 inch). Thus, you can readily see how the reading of .550 inch is obtained on the micrometer scale shown.

Now work out the answers to the problems in figure 171. Write down the answers to these problems and compare them to the correct answers, listed at the end of this chapter.

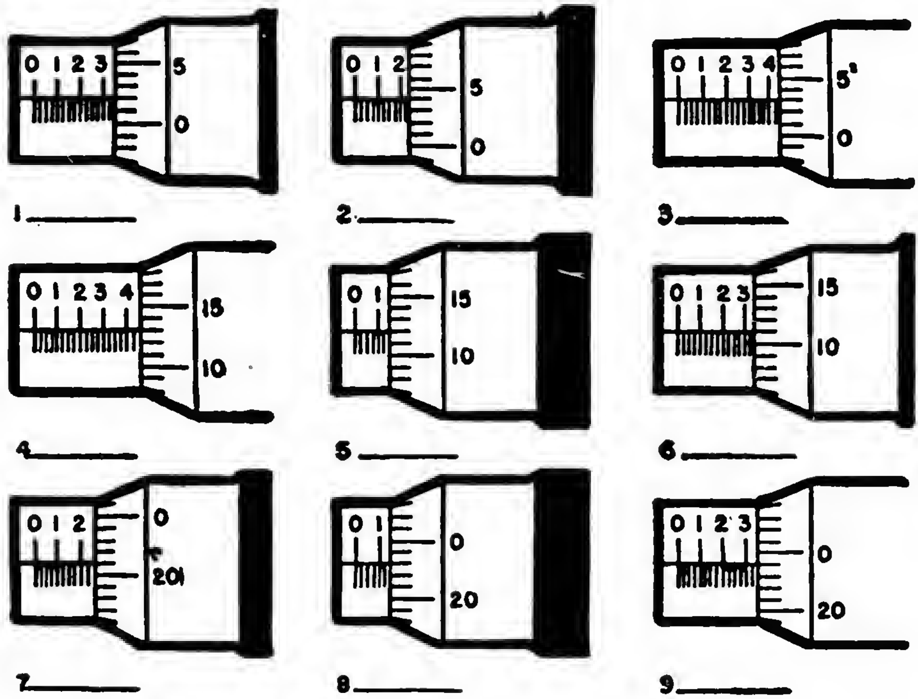


Figure 171.—Mike reading problems.

BETWEEN THE LINES

Perhaps you noticed that in each of the problems in figure 170 the setting is so arranged that a line on the thimble scale is alined with the horizontal mark of the sleeve scale. In actual practice that seldom happens. Usually the horizontal line falls BETWEEN two of the .001 inch markers on the thimble scale. An example of this situation is found in figure 172.

Figure 172 shows a mike reading on which the horizontal line falls between the 14 and 15 marks on the thimble scale. Usually you read to the nearest mark—in this case it's 15, but you can estimate the answer

in ten-thousandths of an inch. It's probably 6 or 7 ten-thousandths in this case, so a close estimate of the correct reading would be .3396 or .3397 inch.

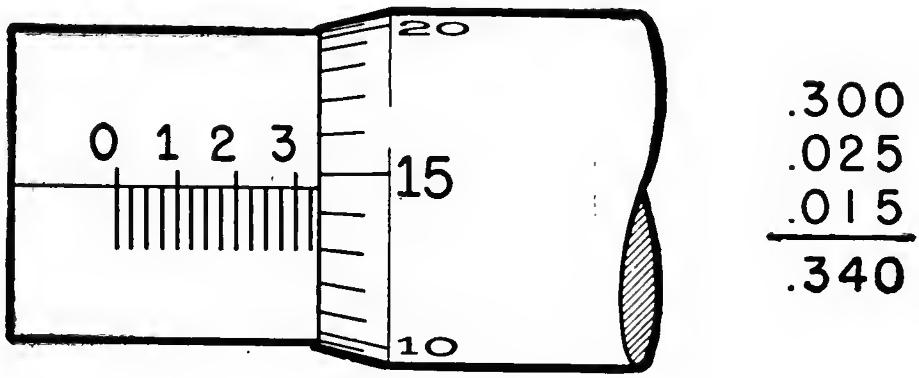


Figure 172.—Reading between the lines.

A special VERNIER scale is added to the better mikes so the user won't have to "read between the lines." One of these scales is shown in figure 173. To read this scale, set the mike and take the reading of the closest

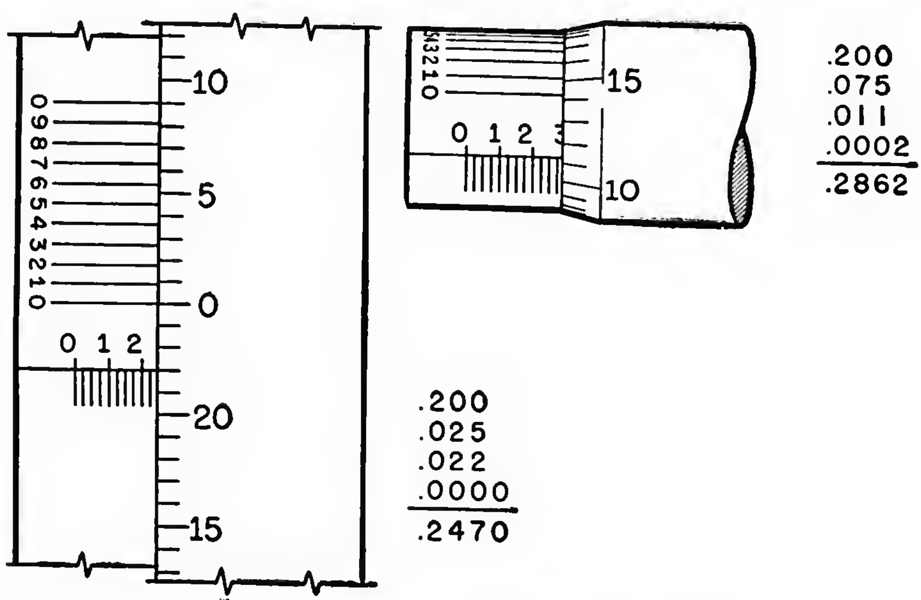
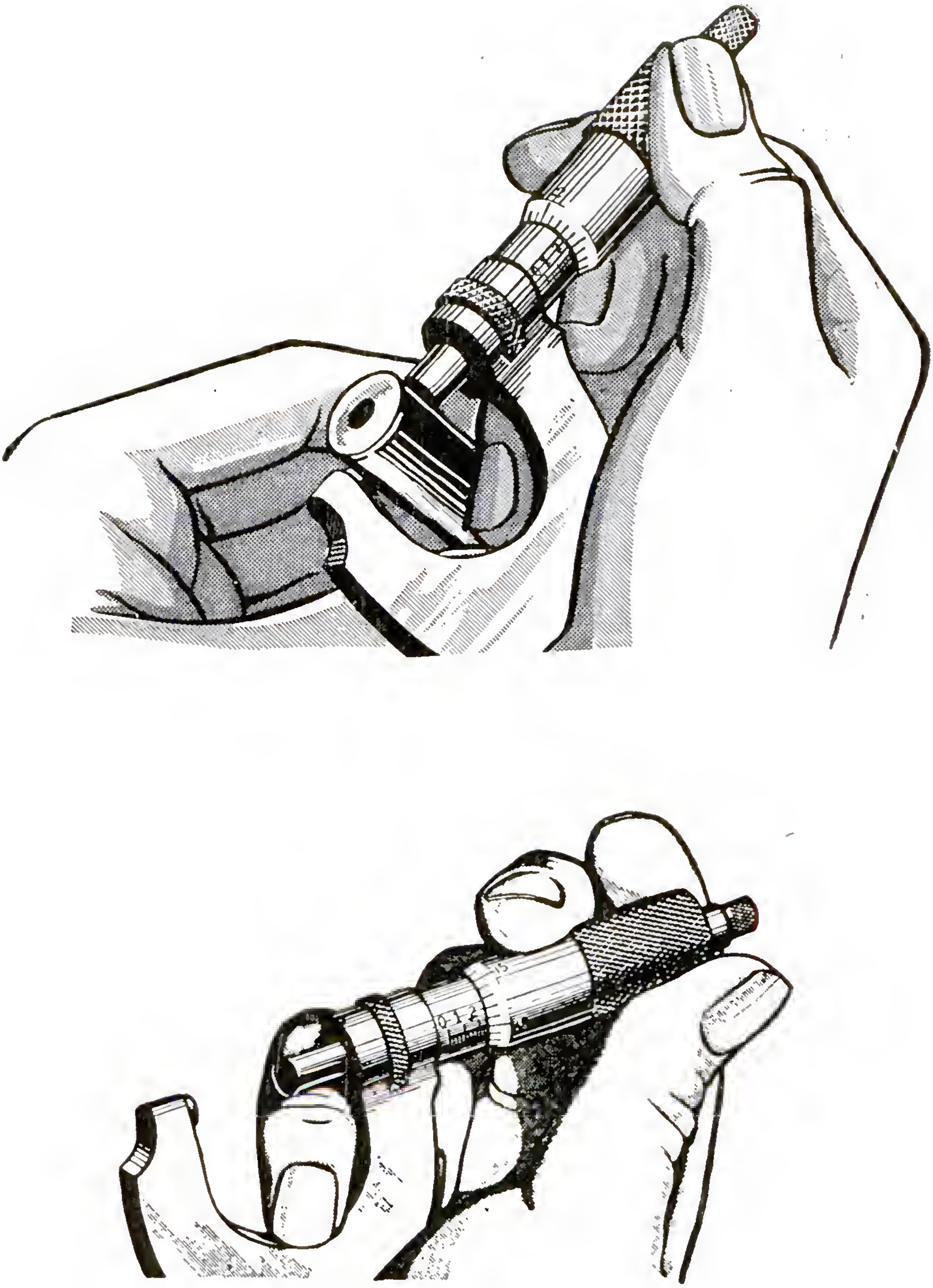


Figure 173.—Vernier scale micrometer.

thimble mark BELOW the horizontal sleeve mark. Then add the NUMBER of the VERNIER SCALE LINE which is in alinement with a line of the thimble scale. The lower



B

Figure 174.—Setting a mike; reading the scale.

scale of figure 173 shows how one of these readings is made.

A micrometer with a vernier scale is often referred to as a TEN-THOUSANDTHS MIKE. You can quickly learn to use one if you make practice readings with it on drill bits, bolts, shafts, etc.

USING THE MIKE

As the mike is a delicate precision tool, you must make every effort to prevent any damage to it. When you are "miking" an object with a 1-inch mike, hold it and adjust it as pictured in figure 174-*A*.

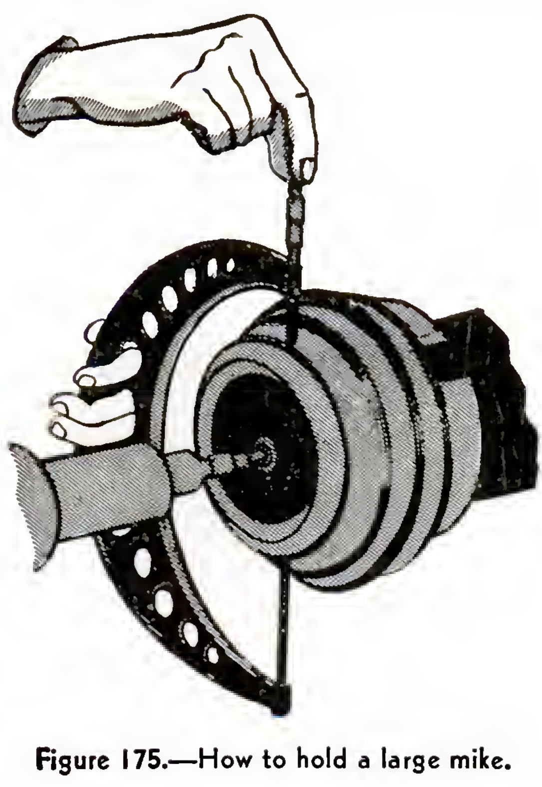


Figure 175.—How to hold a large mike.

After the mike is set, you can remove it from the work to read the scale. Notice how carefully the mike is held in figure 174-*B*. If YOU always clamp YOUR micrometer frame against the palm of your hand with your little finger, there's not much chance that you'll drop it. Large mikes are held and used as shown in

figure 175. Note how the mike is held to prevent it from slipping or dropping.

Most good mikes have a friction SLIP KNOB on the end of the thimble handle. This slips when the mike is set sufficiently tight and insures you against using too much force. Beware of jamming your mike when you take a measurement. And don't slide it back and forth excessively across the stock because it will wear away the ends of both the anvil and spindle.

Mike ANVILS are adjustable, so they can be set to compensate for wear. To set the anvil, you first move the thimble until the scale reads .0000. Then you move the anvil until it fits snugly against the end of the spindle.

Don't allow a micrometer to become rusty or dirty. When you are through using it, wipe it off with a

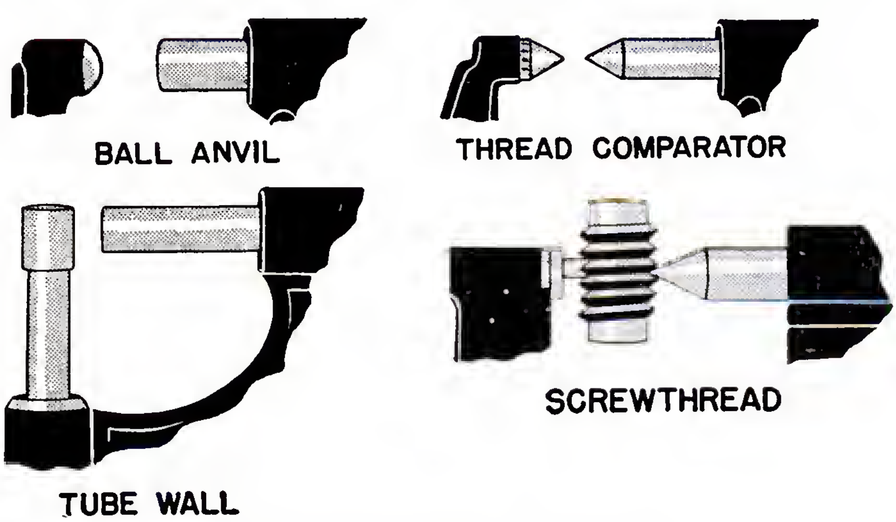


Figure 176.—Special outside mikes.

CLEAN cloth to which a few drops of fine machine oil have been added.

A mike usually comes in a wooden or metal box, with a felt liner. Keep the mike in that box when it is not actually in use. YOU CAN'T BE TOO CAREFUL WITH

A MIKE. Remember that it's a PRECISION TOOL and that its accuracy depends on how carefully you use it and take care of it.

MORE ABOUT MIKES

Not all outside micrometers have plain anvils and spindles. Some have BALL-SHAPED ANVILS and are used to measure the wall thickness of tubes and hollow cylinders. THREAD COMPARATOR mikes have anvils and spindles with cone-shaped points. These mike spindles and points are shown in figure 176, along with those of a SCREW THREAD MIKE. These special mikes are read and used in the same way as an ordinary micrometer.

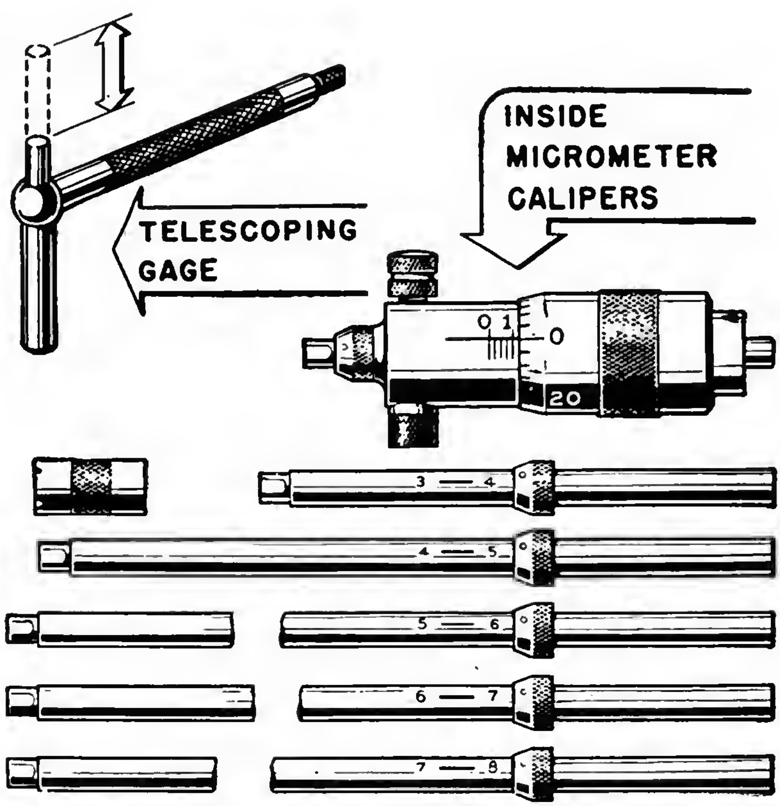


Figure 177.—Inside mike for large diameters.

There are micrometers that can be used to take INSIDE measurements. Two types are commonly used.

The type shown in figure 177 has a scale like an outside mike. It is accompanied by a set of MEASURING RODS that are used to adapt it for making any inside measurement from 4 to 40 inches.

The TELESCOPING GAGE works on the micrometer principle, but has no scale. Its setting is measured with an outside mike.

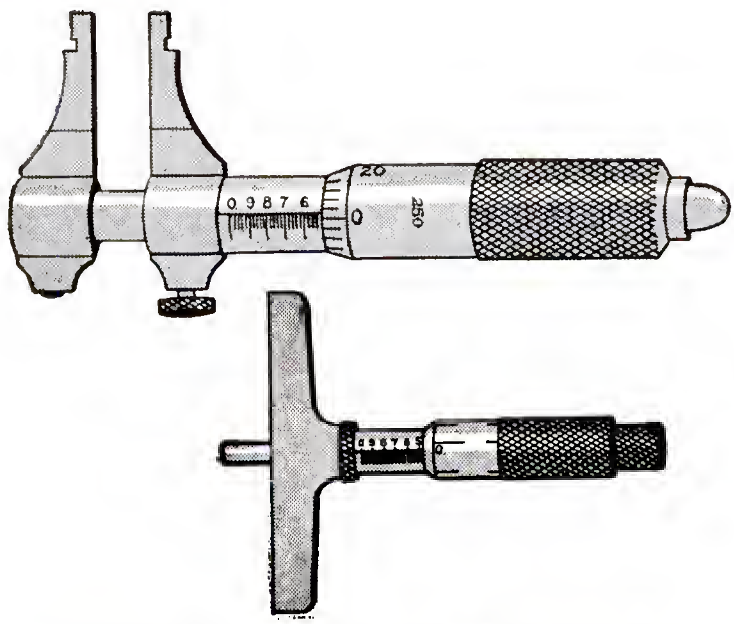


Figure 178.—1-inch inside mike and depth mike.

Inside mikes for small measurements, figure 178, have 2 NIBS that can be adjusted to the desired setting in the same way as the spindle and anvil of the outside mike.

TAKE A GOOD LOOK

Now take a good look at the sleeve and thimble scales of the mike shown in figure 178. Its scale is marked (numbered) in the REVERSE ORDER of that of an inside micrometer. The DEPTH MIKE shown in figure 178, also has this reverse scale. It's used to measure ACCURATELY the depth of blind holes and other recesses.

VERNIER CALIPERS

A VERNIER CALIPER, figure 179, resembles a caliper rule, and is used for the same purpose. The big difference is that the vernier caliper can make PRECISION measurements because it has its own VERNIER SCALE.

The BLADE of one common type of vernier caliper has a scale that's divided into inch spaces. These spaces

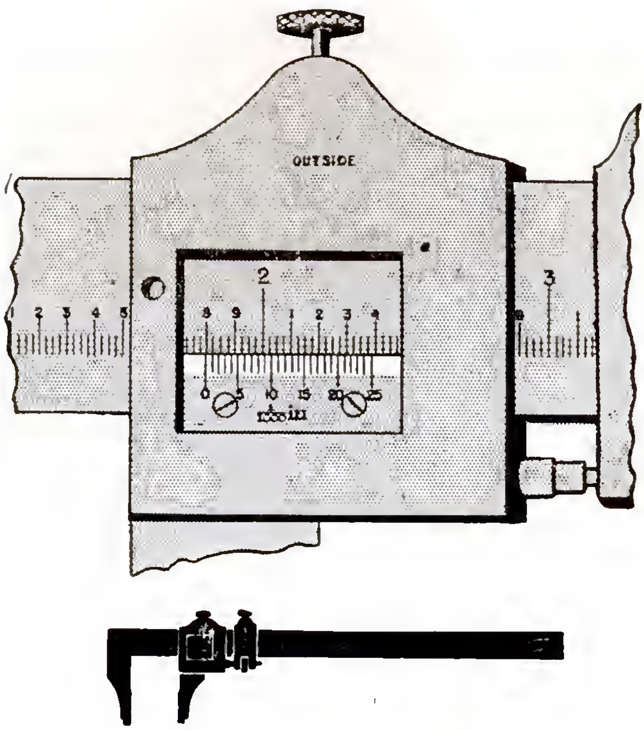


Figure 179.—Vernier caliper.

are sub-divided into spaces of $\frac{1}{10}$ inch (.100) and $\frac{1}{40}$ inch (.025). The SLIDING JAW (slider) carries the VERNIER SCALE. This scale has 25 spaces, each of which is only .024 inch—.001 inch LESS than a small space on the BLADE SCALE. There is a vernier scale on each face of the slider—one marked OUTSIDE (for outside measurements) and the other marked INSIDE (for inside measurements). If you can read one vernier scale you can read another, or any kind of vernier device.

Now, suppose YOU try to make a vernier reading. First set the caliper to the diameter of any convenient shaft or rod, and lock the slider to the blade with the knurled-head set screw. Read from zero (0) on the blade scale to the right, and record the reading to the LAST MARK on the LEFT of the vernier scale (0). Look along the two scales and find a mark on the vernier scale that lines up with a mark on the blade scale. Add the number of that VERNIER MARK to your other readings and you have the correct reading in thousandths of an inch.

The reading of the setting illustrated in figure 179 is 1.789 inches. See if you can figure out HOW that reading is obtained.

A vernier depth gage is shown in figure 180. It is

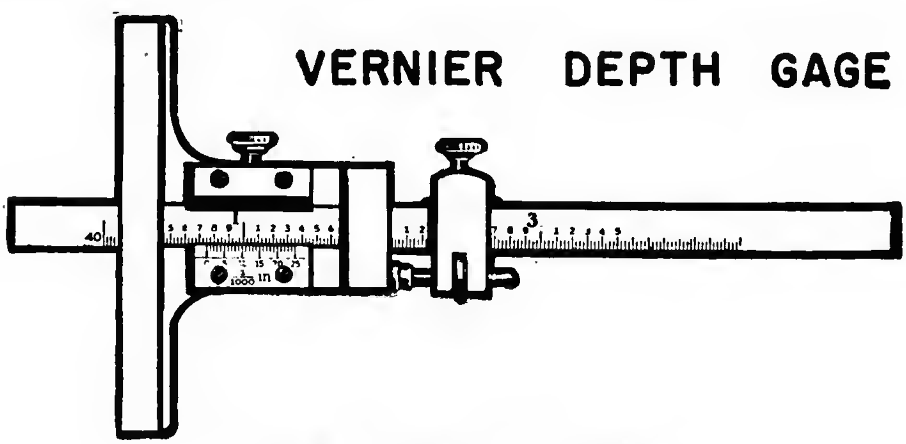


Figure 180.—Vernier depth gage.

set and operated in the same way as a vernier caliper. You will find that the vernier principle is applied to a number of other gages, instruments and tools.

ANSWERS

Here are the correct answers for the mike-reading problems of figure 171. The answers are listed as decimal parts of an inch.

1. .327	4. .438	7. .246
2. .229	5. .137	8. .148
3. .428	6. .336	9. .349

CHAPTER 12

GAGES AND INDICATORS

SHORT CUTS AND SUBSTITUTES

GAGES are used as substitutes for such measuring devices as rules, calipers, micrometers and Vernier devices. Some gages are standard, but others may be designed and made for a special job. You may even make gages yourself (or have a machinist make them) when standard commercial or Navy gages are not available.

Most gages are used for CHECKING MEASUREMENTS. They seldom have any kind of scale that you can read, so if you want to know the size of the gage you must check it with a Micrometer, a Vernier, or with gage blocks.

You'll find that gages are made in many shapes, styles, and sizes. An excellent example of a special

type of gage is the drill gage that you use to determine the size of twist drills. Other gages, such as the feeler gage, have a variety of uses.

THE FEELER GAGE

Any old jalopy will "perk" better if its spark plug gaps are correctly spaced. Perhaps you have used a dime as a FEELER GAGE because you didn't have a regular feeler gage such as is pictured in figure 181. This

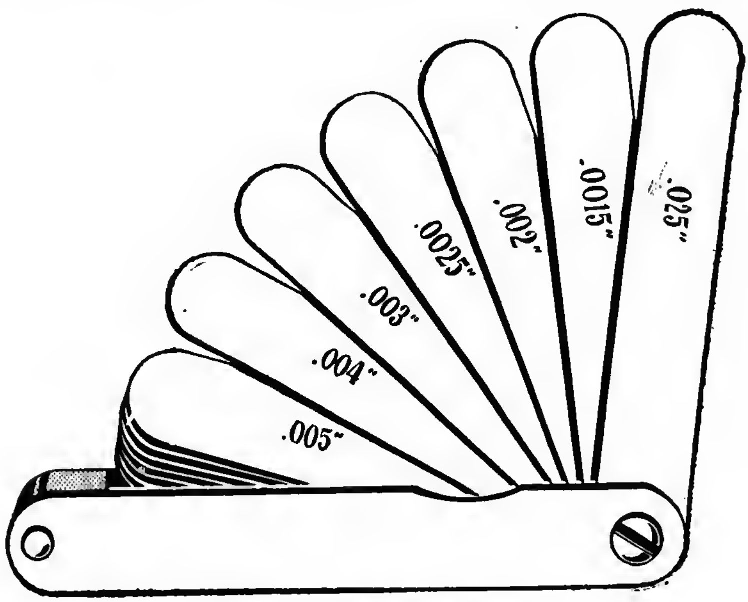


Figure 181.—A feeler gage.

feeler gage, sometimes known as a THICKNESS GAGE, resembles a pocket knife with a lot of blades. All the blades have the same shape, but each blade is accurately ground to a DEFINITE THICKNESS, which is stamped on the blade.

The feeler gage blades usually range in thickness from .0015 inch (about one-half the thickness of a hair on your head) to .025 (about the thickness of your thumb nail). By selecting combinations of two or more blades you can measure any "gap" or clearance up to the total thickness of all the blades.

Notice that the thinner blades are placed between

the heavier blades to prevent kinks and creases. When you use the thinner blades in combination, always try to protect them with the heavier blades of the combination. Wipe the blades with a CLEAN cloth before you use them—otherwise your gage will not measure accurately. Films of oil, grease and dirt make a DIFFERENCE.

The secret of checking "gaps" and clearances ACCURATELY is your ability to "feel" the tension on the blade when you move it back and forth in the space you're measuring. The best way to develop this sense of feel is to practice measuring clearances of known dimensions.

ANGLE AND RADIUS GAGES

ANGLE GAGES and RADIUS GAGES also have blades, but with them it's the blade OUTLINE that's important. Angle gage blades have the same thickness, but each

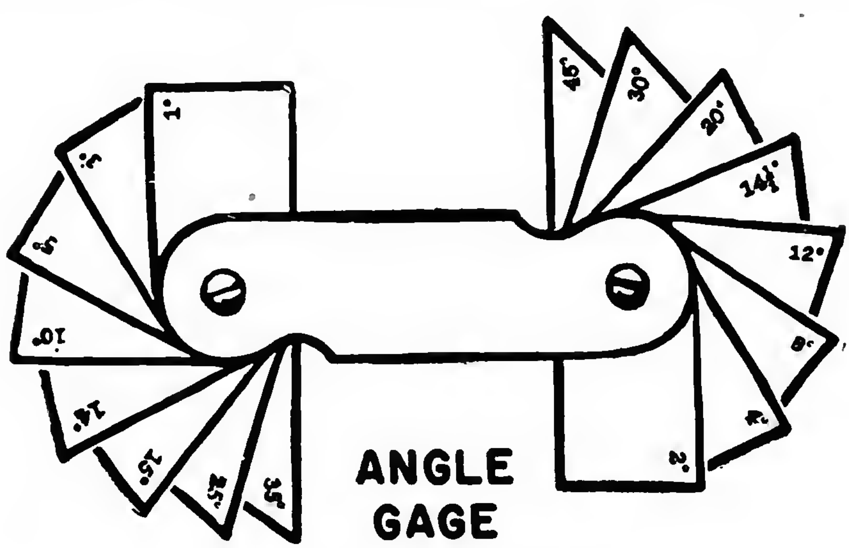


Figure 182.—Angle gage.

blade has a different END ANGLE. These gages are used when it's necessary to measure the same angles frequently. They are substitutes for the bevel protractor,

and are indispensable for measuring angles in restricted spaces where you couldn't possibly use the protractor.

A RADIUS GAGE also has two sets of blades. The rounded corner of each blade is the ARC of a circle. The RADIUS of that arc is stamped on the blade. Ex-

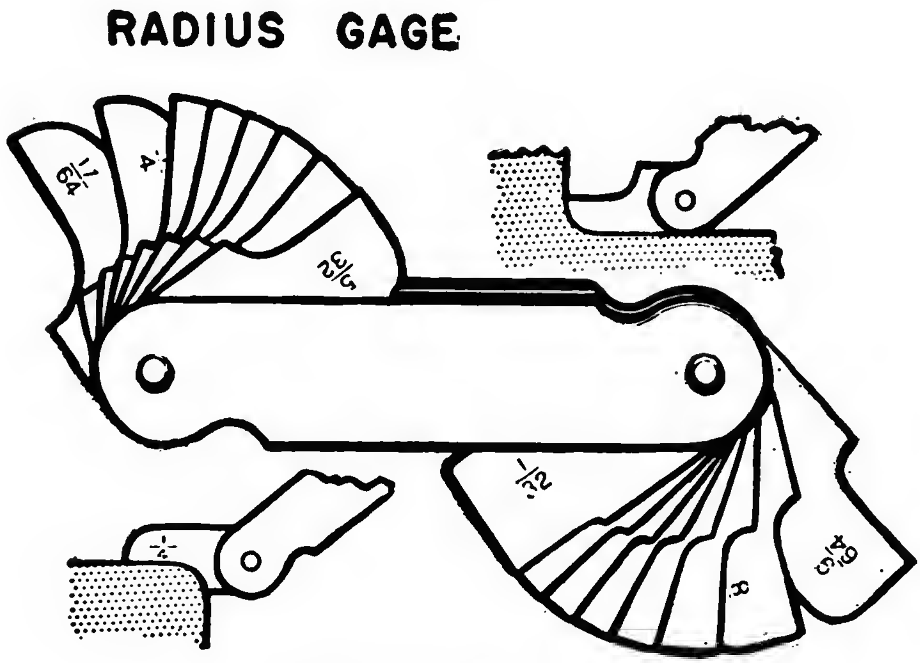


Figure 183.—Radius gage.

amine one of these blades and you'll see that it can be used to check outside radii as well as inside radii. The use of these gages is a "must" for patternmakers and machinists.

WIRE AND SHEET GAGES

The gage shown in figure 184 is a standard SHEET and WIRE gage. It is used to gage cross-sections of wire and to determine the gage (thickness) of metal sheets. You could make these measurements with a micrometer or Vernier caliper, but the simple circular gage is less expensive and a lot handier.

There are several kinds of sheet and wire gages. The one shown is the United States Standard. Others sometimes used are the Imperial and Birmingham

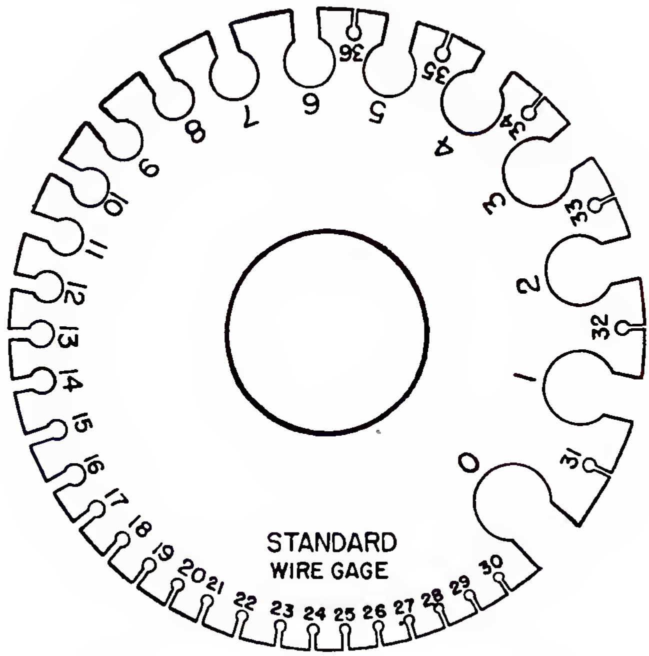
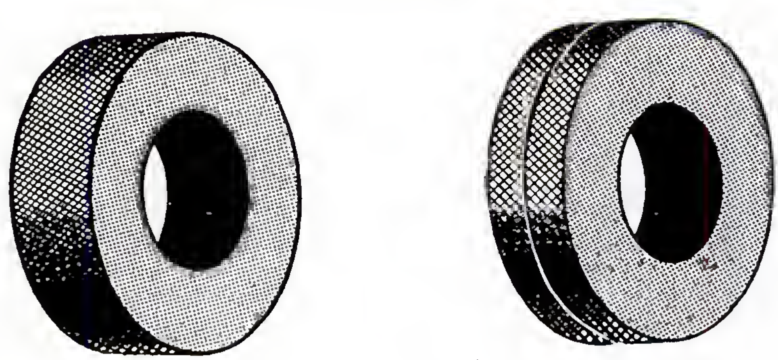


Figure 184.—Wire and sheet gage.

gages. Before you use one of these gages be sure to REMOVE THE BURRS from the sheet metal or wire that you are measuring.

RING AND PLUG GAGES



GO

NO GO

Figure 185.—A set of ring gages.

RING GAGES are used to check the diameters of round machined parts such as shafts, rods and pins. They are carefully machined and ground to size, and each one has its size stamped on it.

Ring gages are usually used in pairs of one "GO" gage and one "NO GO" gage. If the size of the part being checked is within the specified dimensions, the "GO" gage will fit over the work. If the "NO GO" gage can be fitted over the work, it's undersize.

PLUG GAGES, figure 186, are used to check the di-

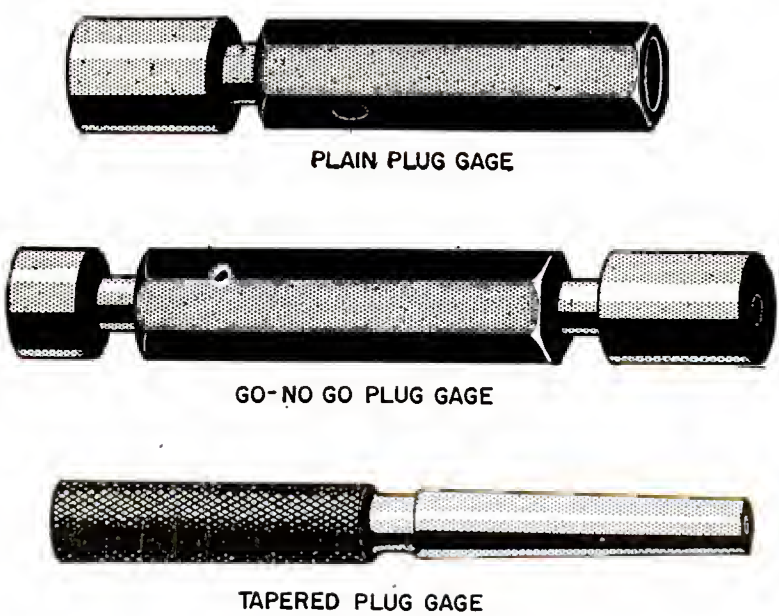


Figure 186.—Plug gages.

ameters of holes. One common type is a combination "GO—NO GO" gage. One end is ground to the minimum diameter allowed for the hole, and the other end is the maximum allowed diameter. Try to insert the ends of this gage into the hole you are measuring. The "GO" end should enter the hole. If the "NO GO" end enters, the hole is too big. The diameter of a plug gage is stamped near the measuring surface.

A TAPERED PLUG GAGE has a long round taper. Di-

ameters may be marked at intervals. You can use one of these gages to estimate HOW MUCH a hole is undersize or oversize. Special taper gages are used to check tapered holes.

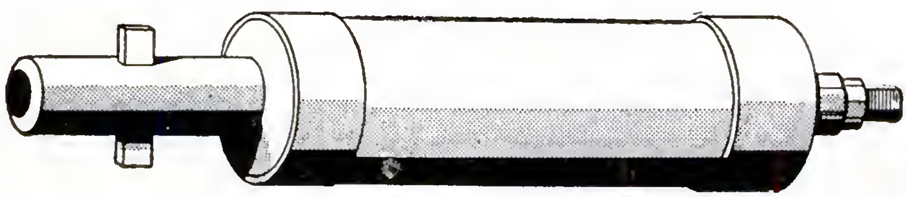


Figure 187.—Gun-bore plug gage.

The BORE GAGE is one type of plug gage that is used a lot aboard ship. Gunner's Mates push it through the bore of a gun to make sure that the diameter of the bore is large enough—AT ALL POINTS—to allow the projectile to pass through the bore. Individual plug gages are provided for each bore size.

SNAP GAGE

A SNAP GAGE is used in much the same way as a ring gage, but it can be used to check the outside diameters of shafts on which it is impossible (because of construction) to use a ring gage. The gage shown in figure 188-*A* is a combination SNAP AND RING GAGE.

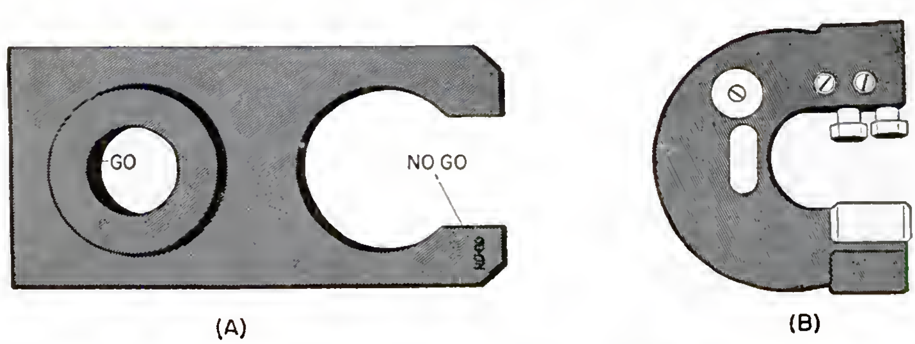


Figure 188.—Combination ring snap gage; adjustable snap gage.

ADJUSTABLE SNAP GAGES have anvils that can be set to the desired dimensions with a micrometer or with gage blocks. The gage shown in figure 188-*B*

has TWO adjustable anvils—one is set for the allowable minimum diameter and the other for the allowable maximum diameter.

GAGE BLOCKS

You may or may not get a chance to see—or use—a set of GAGE BLOCKS, but you should KNOW about them. These blocks are the ULTIMATE in ACCURACY. They are used as MASTER GAGES—other gages are set to them and checked against them.

Gage blocks are manufactured in standard thicknesses. Combinations of two or more blocks are used to obtain any desired thickness. The best gage blocks are machined and ground so carefully that THEY ARE ACCURATE WITHIN A FEW MILLIONTHS OF AN INCH. They are so close to being perfectly flat that two of the blocks will stick together when one is placed in contact with the other.

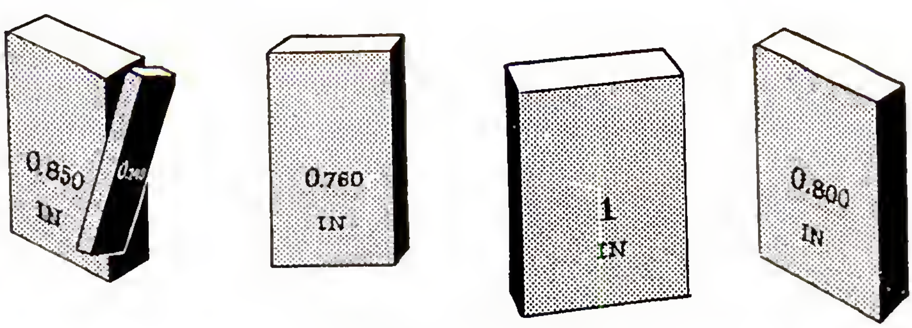


Figure 189.—Gage blocks.

These gage blocks are often called "Jo-blocks" because the first really good ones were made by a man named Johansson. A complete set of Johansson gages includes 81 blocks.

Sets of these super-accurate blocks are kept in dust free, dry, air-conditioned rooms. The temperature of these rooms is maintained at a constant level to prevent changes of dimensions as a result of expansion and contraction.

SURFACE GAGE

A SURFACE GAGE is used to measure height, and for scribing layout lines on vertical surfaces. The commonly used UNIVERSAL type, figure 190, has a base plate, an adjustable extension arm, and an adjustable scriber. When a surface gage is set to a combination-

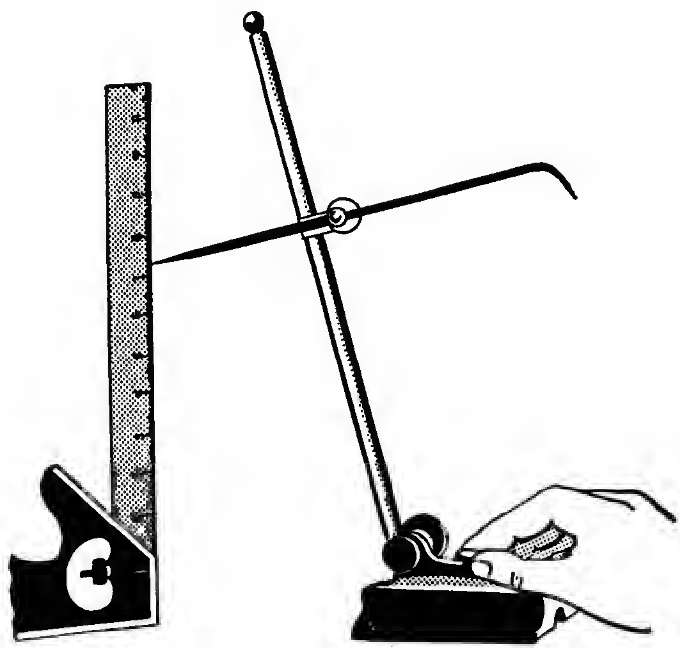


Figure 190.—Setting a surface gage.

square blade, as shown in figure 190, both the square and the gage base must rest on a flat, smooth surface —preferably a surface plate.

You may have occasion to mount a DIAL INDICATOR, shown in figure 191, on the surface gage extension arm and use that set-up to check the trueness of round objects. A shaft may be checked in this way. You set the gage in position and turn the shaft slowly. If the shaft is not true the dial hand will indicate the deviation.

A DIAL INDICATOR has a contact point that bears against a shaft or rod to check its alinement. The

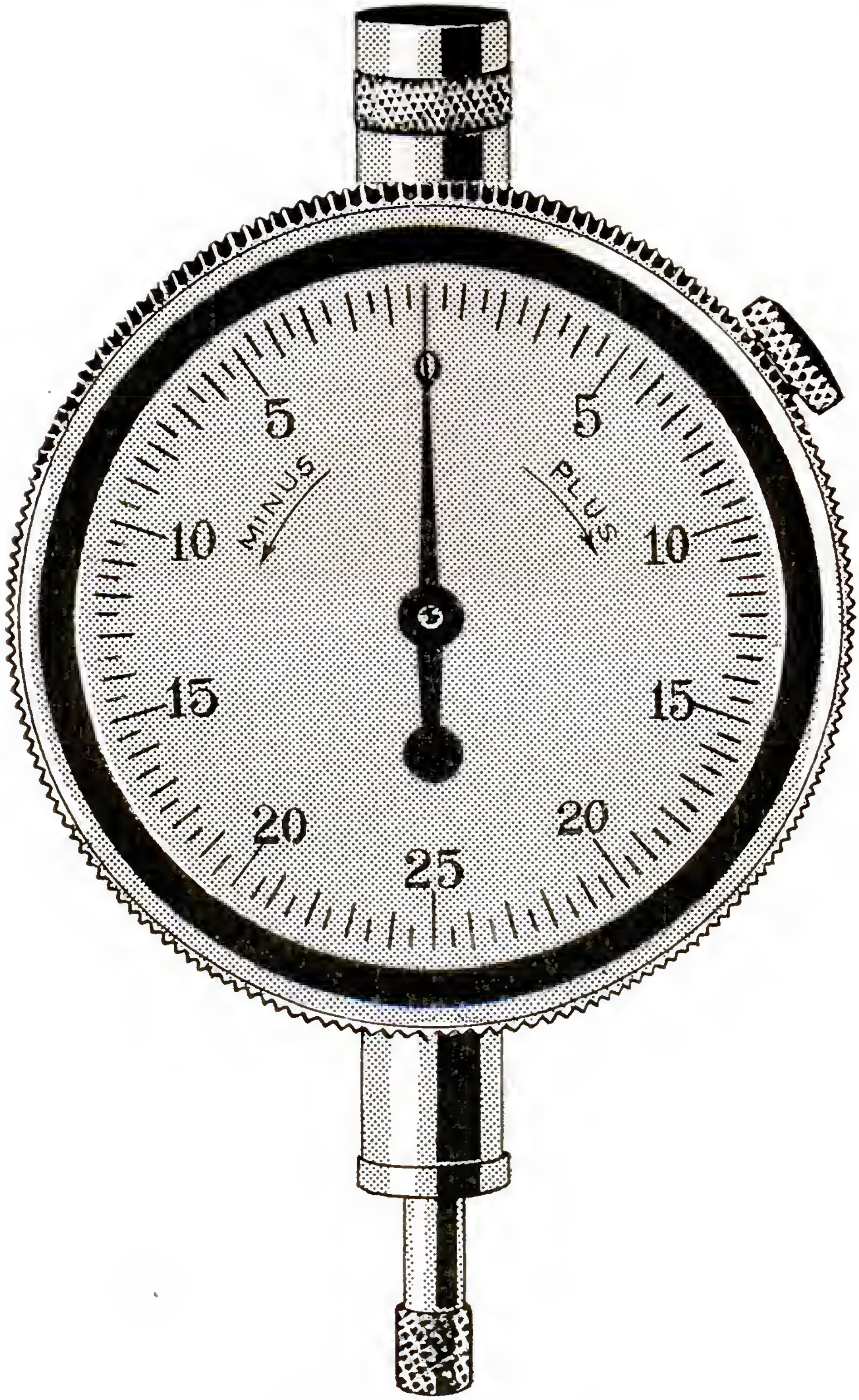


Figure 191.—Dial indicator.

common dial indicator, figure 191, has a dial that's graduated in thousandths of an inch—both PLUS and MINUS.

This indicator is often used by fire controlmen, torpedomen, machinist's mates and other rates to check the alinement of shafts. The simple dial indicator is usually used with the attachments and accessories pictured in figure 192. The base has T-slots,

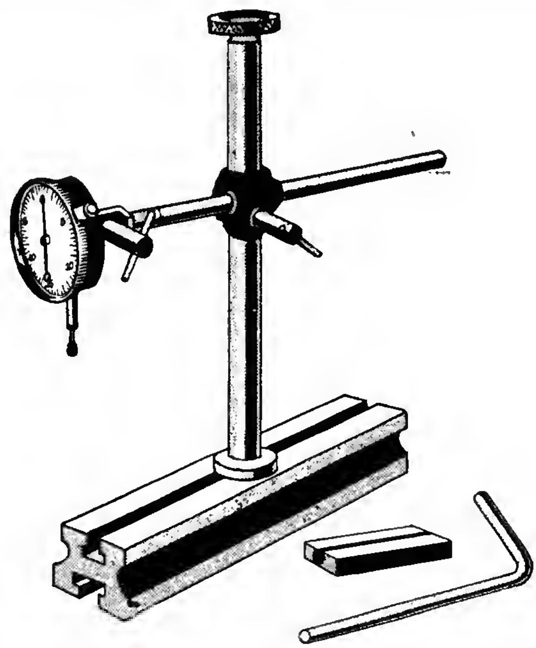


Figure 192.—Dial indicator set-up.

one of which is used to clamp the main post. This post has an adjustable clamp which holds the indicator arm in the desired position. The base should be clamped securely to a solid object when the dial indicator is being used.

If you ever have to work in a large repair shop, instrument shop, experimental laboratory, or on a repair ship, you will see and use many types of dial gages. Some will be as simple as the one shown, but others will be even more ACCURATE—and more versatile. They are designed to handle a great variety of jobs.

SPEED INDICATOR

When you need to KNOW the number of revolutions per minute (rpm) of an electric motor, a line shaft, or other revolving part, you can easily secure the information with a SPEED INDICATOR, figure 193. It's also known as a REVOLUTION COUNTER.

This tool has a set of interchangeable rubber tips that fit on the spindle. Cone-shaped, flat end, and vacuum tips are usually supplied with the indicator.

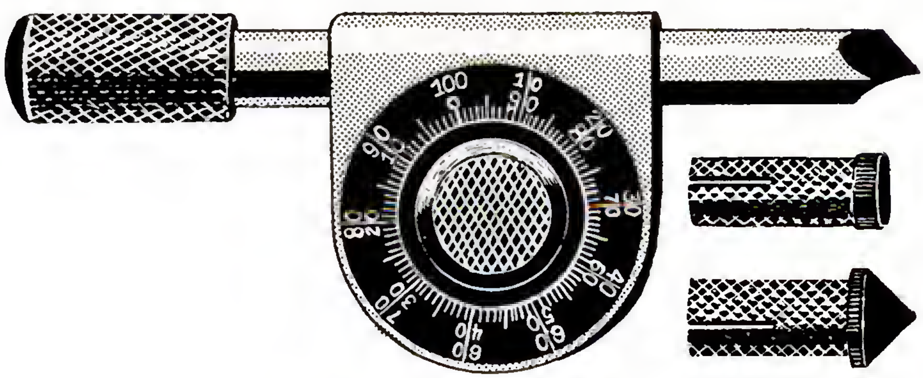


Figure 193.—Speed indicator.

The cup-like vacuum tip works best on the flat end of a shaft; the cone tip is best if the shaft has a countersunk end.

When you use one of these indicators, the TIME ELEMENT must be considered. You can use a wrist watch which has a second hand for timing, but you'll get better results with a stop-watch.

A TACHOMETER (not shown) is a type of revolution counter that constantly indicates the revolutions per minute of an engine or motor. It resembles an automobile speedometer. Some tachometers record the engine speed on a time chart.

SMALL-HOLE GAGES

How can you find the diameter of a small hole? One common method is to find a twist drill that just

fits in the hole. The diameter of the hole will be the same as the diameter of the drill. That system is OK, IF you're lucky enough to find a drill that fits, and IF absolute accuracy isn't all-important.

The SPLIT-BALL type of SMALL-HOLE GAGE is designed for accurate determination of the diameters of small holes. There are usually four of these gages in a set, designed to measure any hole diameter up to ½ inch.

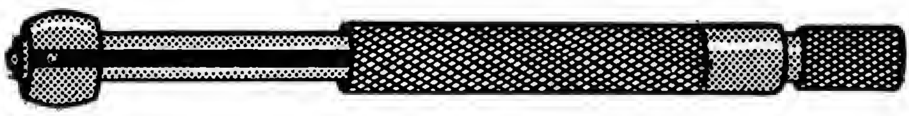


Figure 194.—A small-hole gage.

To use this gage you merely lower the ball end into the hole and expand the two halves by turning the handle. When the "setting" is just right, lock the gage with the knob at the end of the handle. Then you can withdraw the gage from the hole and measure the "setting" with a micrometer or vernier.

CARE OF GAGES AND INDICATORS

All PRECISION tools and instruments must be handled with the greatest of care, and should be cased in special boxes or containers when they are not in use. Gages and indicators demand the same respect you naturally have for a compass, a chronometer, or a pair of binoculars.

Precision tools won't retain their ACCURACY if allowed to become rusty, bent, or dented. An ounce of prevention is worth much more than a pound of cure. That's why you must keep precision equipment coated with a thin film of CLEAN OIL to prevent rust, and adequately cased to prevent damage. Remember, it's impossible to be too careful when you use precision tools, gages, and indicators. It's INEXCUSABLE to drop any of them at any time.

Never use emery cloth, sandpaper, steel wool, or any other abrasive, to clean the MOVING PARTS of a precision tool or instrument. Those moving parts are machined and ground to exceptionally close tolerances. If you wear away some of the metal you ruin the FIT of the parts and impair the ACCURACY.

CHAPTER 13

SPECIAL TOOLS

GET ACQUAINTED

A good baseball pitcher doesn't depend on his fast ball alone. He needs a good assortment of curves, drops, inshoots, and slow balls if he expects to be a winning pitcher. These pitches are the "tools" of his trade, and he works hard to master all of them. In like manner you need to know how to use all the tools of YOUR trade. Not only should you thoroughly understand the tools of your own RATE, but you should know something of the tools of other rates. Some of the tools described and pictured in this chapter are used by only one or two rates. This is particularly true of some of the SPECIAL TOOLS used by metalsmiths, molders, shipfitters, etc., and some that have been developed for other special jobs. Many of these tools are designed to do only ONE job—a job that's a tough proposition with ordinary tools. But you never know when YOU may need to use one of these tools, so it will pay you to be familiar with their names and uses.

The more tools you can use, the better workman you will be. When you observe someone using a tool that's new to you, find out all you can about it. Ask WHAT IT IS, HOW IT WORKS, and the JOBS IT WILL HANDLE. You can't know too much about tools.

SHEET METAL TOOLS

A sheet metal worker does a lot of his work with such tools as snips, hammers, pliers, etc., but special tools have been developed to make his work faster, more simple, and better. One of these special tools is the CIRCUMFERENCE RULE.

Suppose you're going to make a small tank that has a diameter of 9½ inches. What's the circumference?

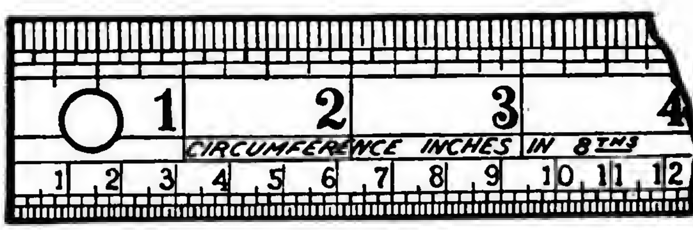


Figure 195.—Circumference rule.

You can sit down and multiply 9½ times 3.1416 (pi) to get the answer—but that takes time. It's all figured out for you by the circumference rule, shown in figure 195.

This special rule has two scales on the same face. One is a regular scale of inches, with subdivisions of $\frac{1}{16}$ inch. You might call this scale the DIAMETER SCALE. The other scale, the CIRCUMFERENCE SCALE, is marked off in inches and ⅛ inches but these spaces are NOT TRUE LENGTH. One "inch" on the circumference scale is equal to 1 inch DIVIDED BY 3.1416.

To use this rule you merely select the desired diameter on the DIAMETER SCALE and read straight across the rule to the CIRCUMFERENCE SCALE to obtain the circumference. Simple, isn't it? And it saves a lot

of time while eliminating the possibility of mathematical error.

Sheet metal STAKES are steel forms and shapes on

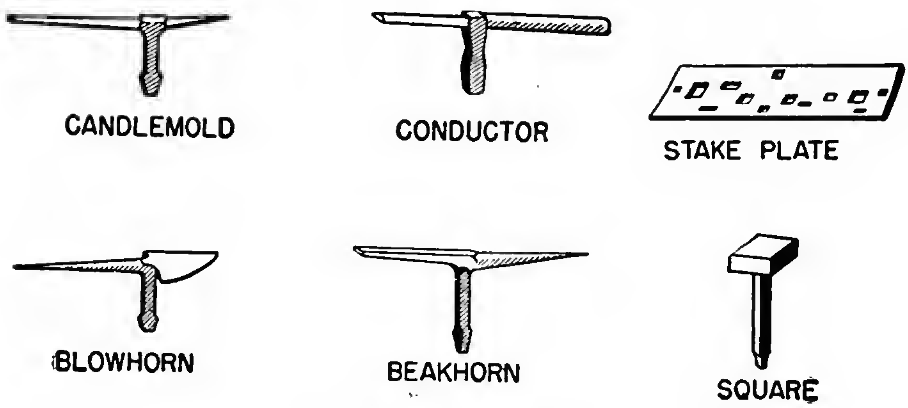


Figure 196.—Stakes.

which sheet metal may be worked. Some of the stakes are handy to use for riveting—the rivet head being "backed up" by the stake head. These stakes are made in a great variety of shapes and sizes. Some of the stakes you may use are pictured in figure 196.

Some stakes come in sets, and each stake may be clamped in a holder. The most commonly used stakes are made with square, tapered shanks, shaped to fit

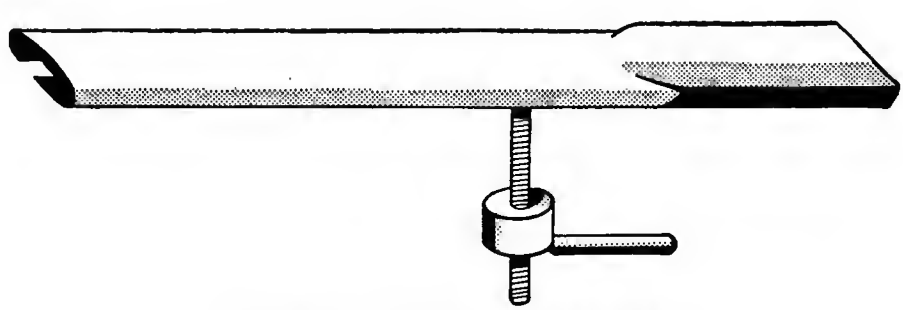


Figure 197.—Hollow mandrel stake.

in the STAKE PLATE. This is a heavy cast-steel plate that is usually built into a bench top. The plate has slots which fit the various sizes of stake shanks.

The HOLLOW MANDREL stake, figure 197, is not used with the stake plate, but is secured to the bench top with a special clamping bolt. The stake can be moved to the desired position and locked in place with the clamping device.

The HAND GROOVER is used to lock sheet metal seams,

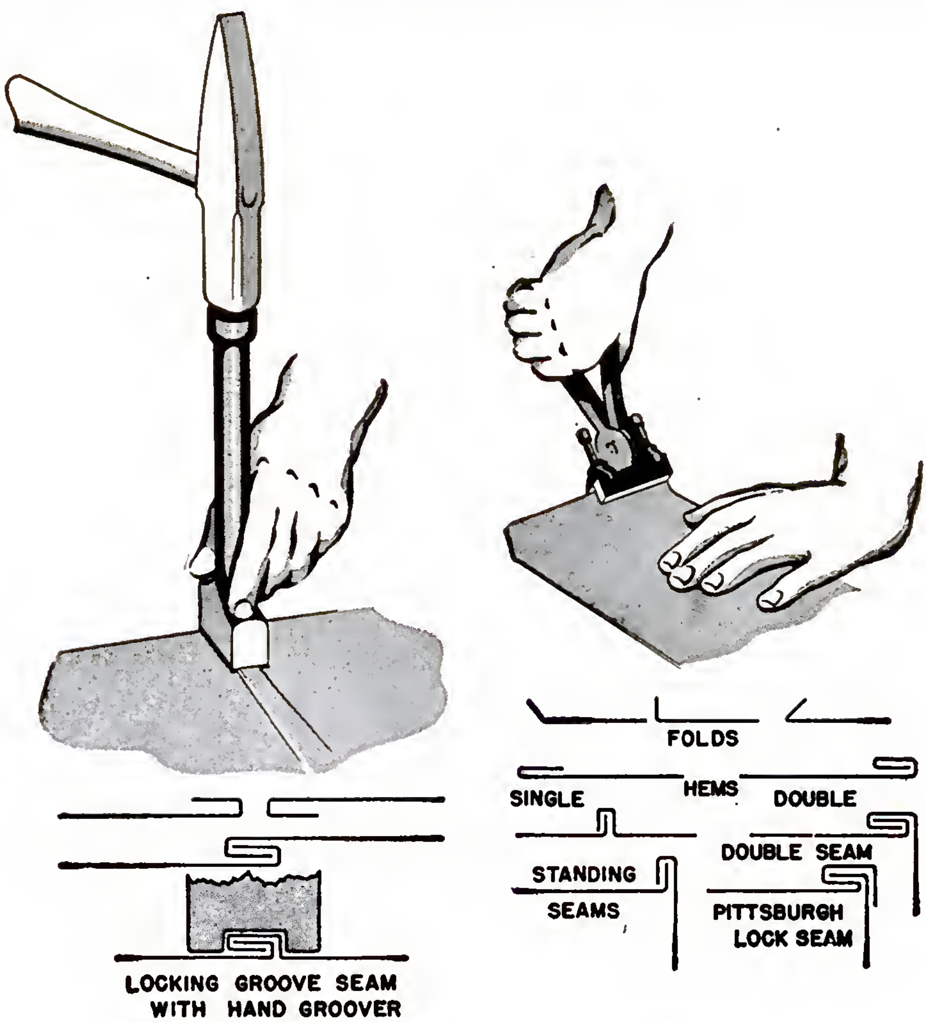


Figure 198.—Hand groover; hand seamer.

as shown in figure 198. Seams made this way are known as GROOVED SEAMS—the kind used on buckets, air ducts, tin cans, etc.

The HAND SEAMER, figure 198, is used to bend and form edges of metal sheets in making seams. The

seamer is like a pair of pliers with extremely wide jaws. You use it if you do not have a BAR FOLDER—a small bench machine used to turn sheet metal edges for seams and hems.

FORGING TOOLS

The village blacksmith stood under the chestnut tree and beat out horseshoes on an ANVIL. The anvil is still one of the metalworker's handiest tools. The face or main working surface of the anvil is made of tough steel. A square hole extends through the anvil top to hold the HARDIE, shown in figure 199. The hardie is used for cutting metal bars and rods. The

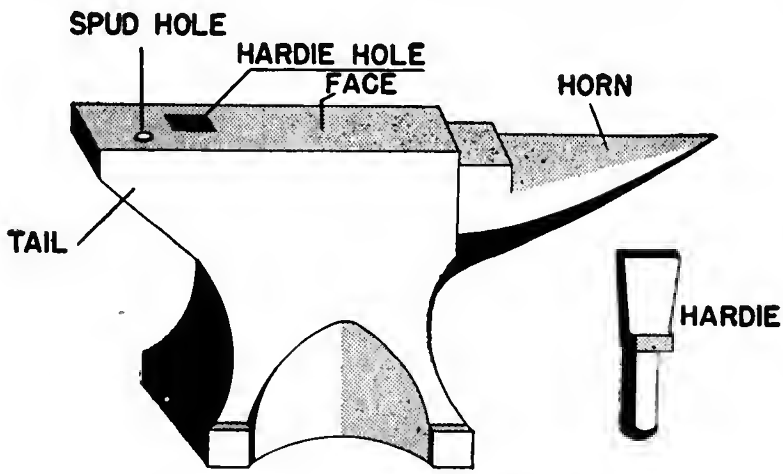


Figure 199.—Anvil and hardie.

metal to be cut is placed over the hardie and struck with a hammer or sledge.

The end of the anvil opposite the hardie hole has a pointed or cone-shaped HORN, over which curved portions of bars and rods may be formed.

The top surface of the anvil should be treated with care so as to avoid dents and scratches. Its primary purpose is to provide a working surface that will support the metal while it is being pounded into shape. This surface forms or shapes part of the object being forged, so the smoother it is the better job you will get. Don't cut metal on the anvil with a chisel unless you're

certain the chisel will not damage the face of the anvil.

MAULS or SLEDGES, used for heavy forging, weigh from 5 to 20 pounds. The heads of these oversize hammers may have two flat surfaces (double-faced), a cross-peen, or a straight peen.

SWAGES are used in matching pairs to shape round or oval objects. FULLERS are used to shape round

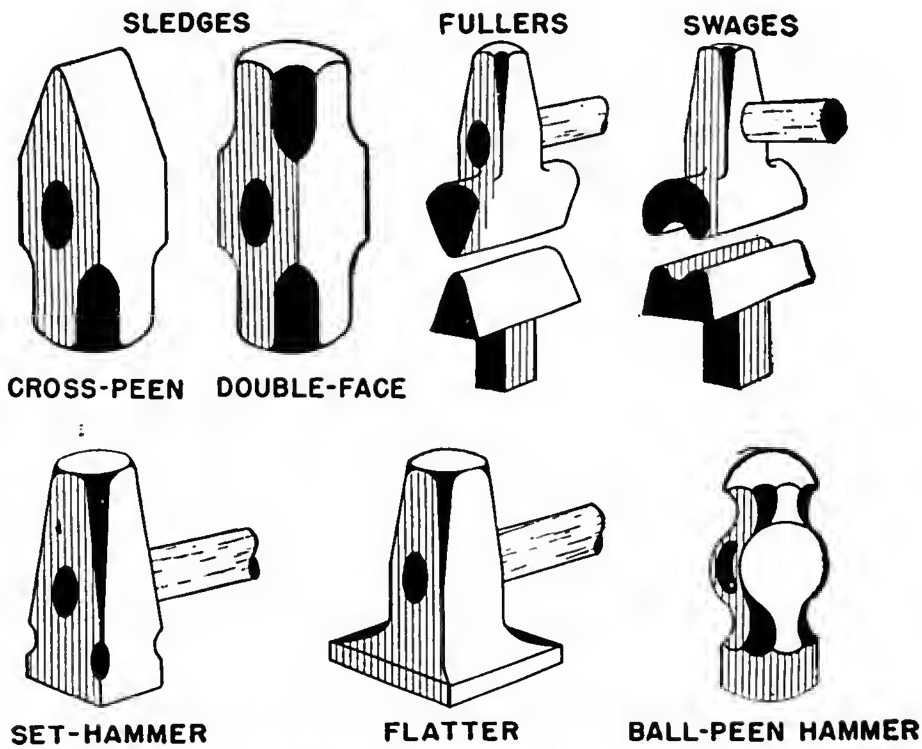


Figure 200.—Sledges and hammers.

inside corners and inside angles. The SET HAMMER and the FLATTER are used to smooth and finish flat surfaces. These tools are all shown in figure 201.

TONGS are used for handling hot pieces of metal. Their jaws differ according to use—otherwise the many varieties are much alike.

The HOT CHISEL, figure 201, is really a special hammer with a chisel edge. It is used only when you want to cut HOT metal. To use it, place the metal on the

anvil, set the HOT CHISEL cutting edge in place, and strike the other end of the head with a hammer or maul. Don't cut into the anvil. Put a piece of scrap under the work when you want to cut completely through a piece of stock.

The COLD CHISEL, figure 201, is heavier and stronger than the hot chisel. It also has a handle so you can hold it in place while you pound on it.

PUNCHES are used to punch holes in HOT metal. In addition to the ROUND PUNCH shown in figure 201,

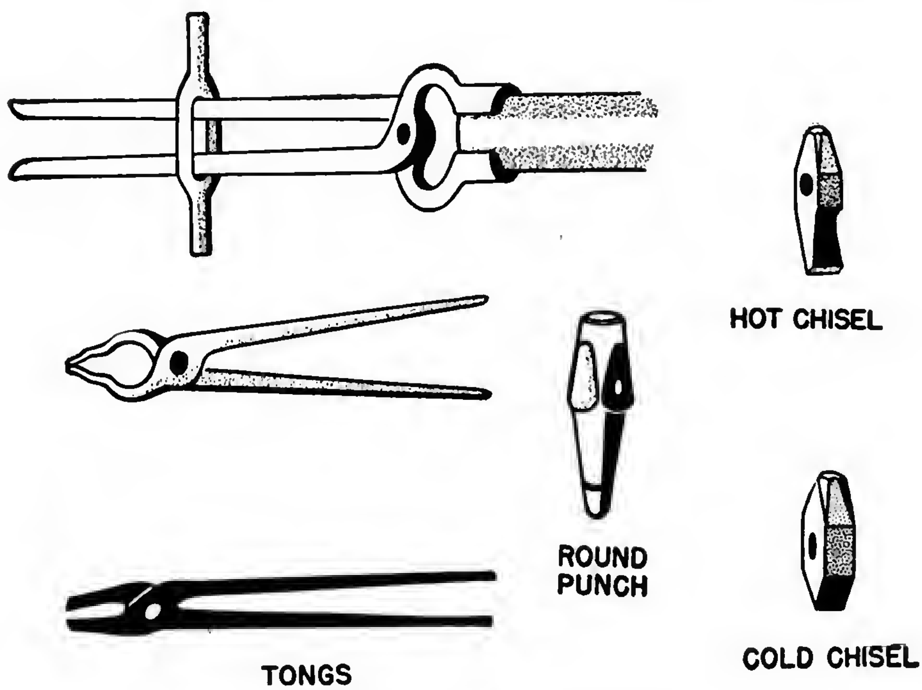


Figure 201.—More forging tools.

most shops have punches that are square, rectangular, half round, oval, etc. They too are used only on HOT metal.

MOLDING TOOLS

The MOLDER is the "sandman" of the Navy. He makes SAND MOLDS, or forms, into which molten metals are poured to produce castings. As most of his work

is done with sand, the majority of his tools are especially designed for handling and working sand.

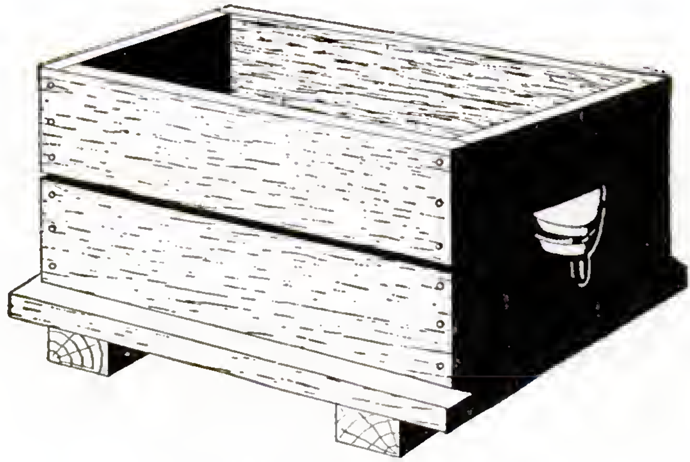


Figure 202.—Molder's flask.

Molds are made in wood or steel FLASKS. A flask has two or more parts. A two-part flask is shown in figure 202. The DRAG is the bottom part; and the COPE is the upper part. Other sections placed between the drag and the cope are called CHEEKS.

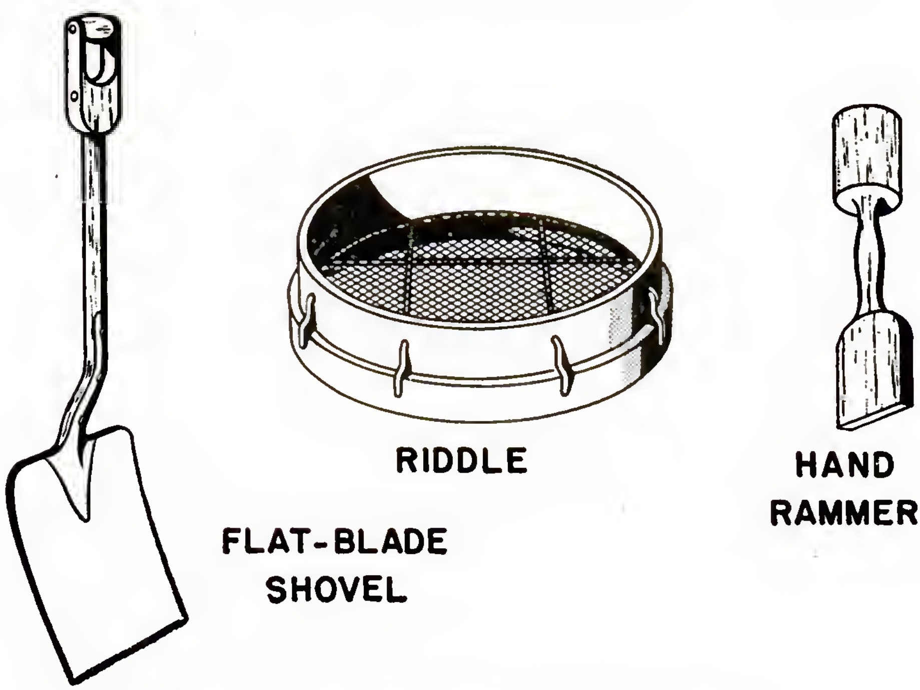


Figure 203.—Molder's shovel, riddle, and rammer.

The FLAT BLADE SHOVEL is used to "cut" and mix sand that is being "tempered" (moistened with water). It's also used to move sand from the bin (or pile) to the riddle or flask. The RIDDLE (or sieve) is used to remove lumps, large grains, nails, scrap metal, etc., from the sand. After a layer of sand is riddled into the drag or cope it is "tucked" around the pattern with the fingers. More sand is then added and rammed (packed) with the RAMMER, one type of which is shown in figure 203.

Large foundries have pneumatic rammers—much like pneumatic hammers or chisels.

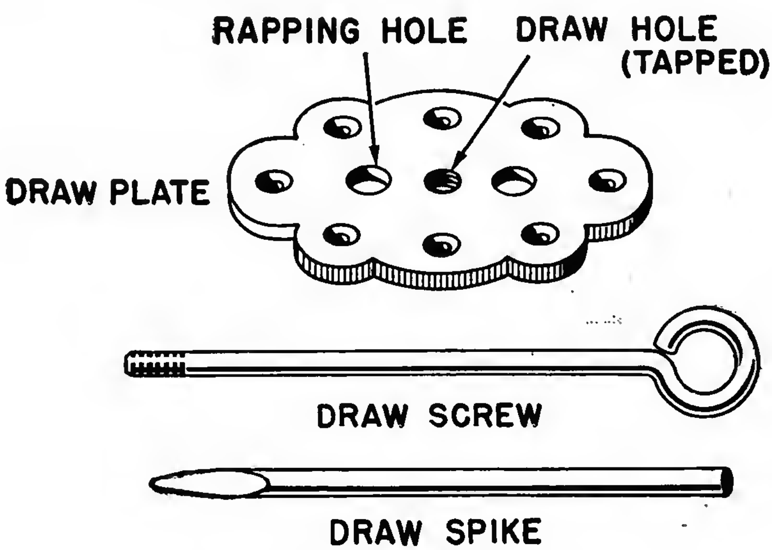


Figure 204.—"Drawing" tools.

After the sand is rammed, the parts of the flask are separated and the wooden pattern "rapped" (vibrated) and "drawn" (pulled from the sand). The pattern is drawn with a DRAW SPIKE or a DRAW SCREW.

A DRAW PLATE is usually built into the pattern and the draw screw or spike fits into holes in that plate.

When the pattern is drawn from a mold, the sand in the mold is often disturbed or broken loose. The molder has special repair tools to smooth and reshape the surfaces and corners of the mold.

The MOLDER'S BULB is used to moisten the sand in damaged areas, before the repair work is started. TROWELS, shaped as shown in figure 205, are used to smooth large surfaces. SLICKS are used to smooth small areas and curved surfaces of the mold. These tools have thin handles with miniature trowels on each end. A variety of shapes and sizes is used.

LIFTERS are used to remove loose sand from re-

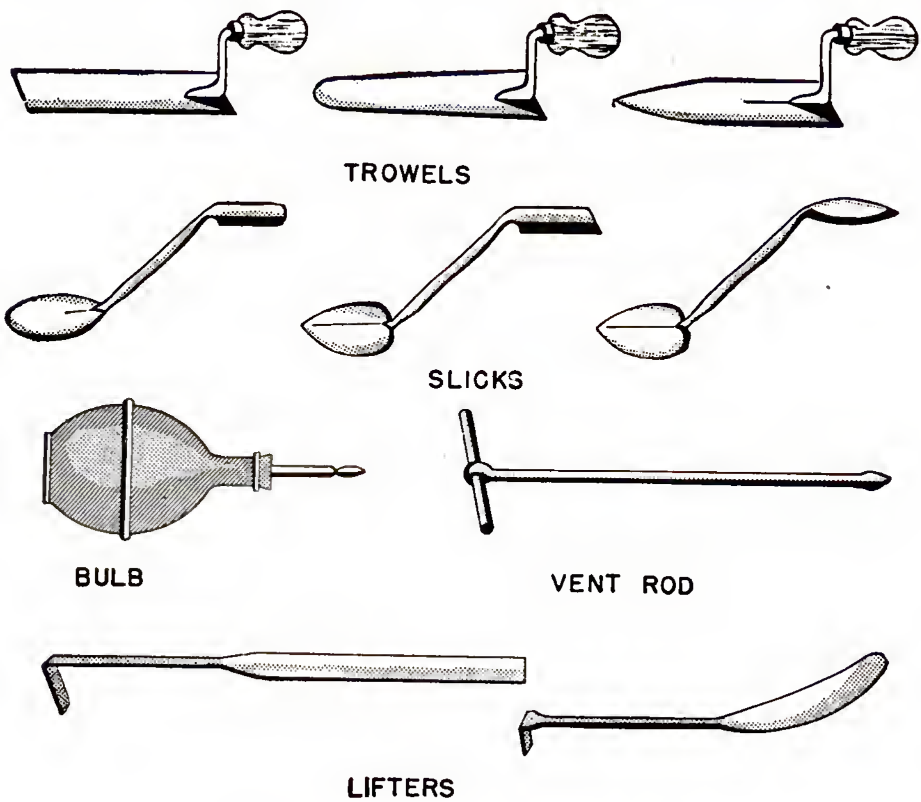


Figure 205.—Mold repair tools.

cesses in the mold. The flat end is sometimes used as a slick, or as a knife to cut away sand.

VENT RODS are not repair tools but are used to make VENTS or channels in the sand mold, through which gases (released when the hot metal meets the damp sand) may escape. If these gases could not escape quickly they would exert enough pressure to ruin both the mold and the casting.

When you want to open a large crate, you reach for the old reliable PINCH BAR, of course. One common type has a pry wedge at one end and a curved claw at the other. It's the best kind for opening crates.

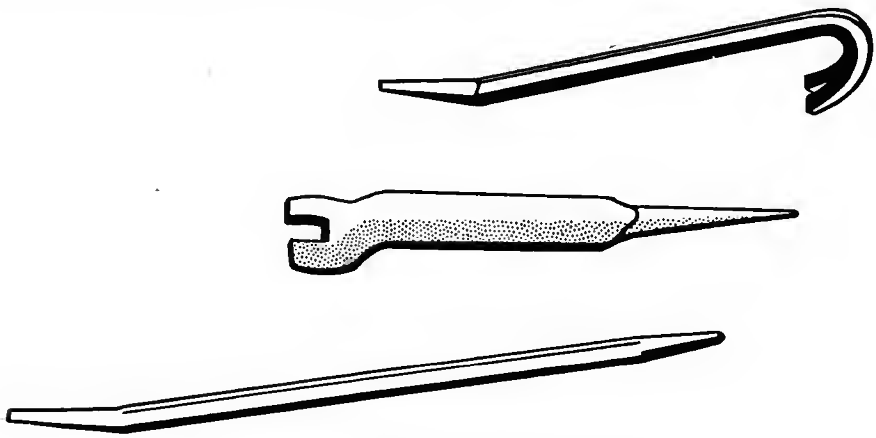


Figure 206.—Pinch bars and spud wrench.

Another type has one pry end and one long, round, tapered end. The tapered end is used by shipfitters as an alinement tool for bolt and rivet holes.

The SPUD WRENCH, figure 206, is a combination open-end wrench and alining tool. It's one of the shipfitter's handiest tools.

GASKET CUTTERS, figure 207, are used to cut round gaskets from sheets of gasket stock—cork, rubber, leather, asbestos, fiber, composition, etc. One type of these tools has two adjustable cutters. One makes the inside hole; the other forms the outside of the gasket. A gasket cutter has a shank like an auger bit, and it's held in a brace while you use it.

FLY CUTTERS are designed to cut holes in sheets of soft metal—brass, aluminum, soft steel, etc. They may also be used to cut holes in sheets of fiber, bakelite, plastics, and similar materials. The one shown has one cutting bar but some have two.

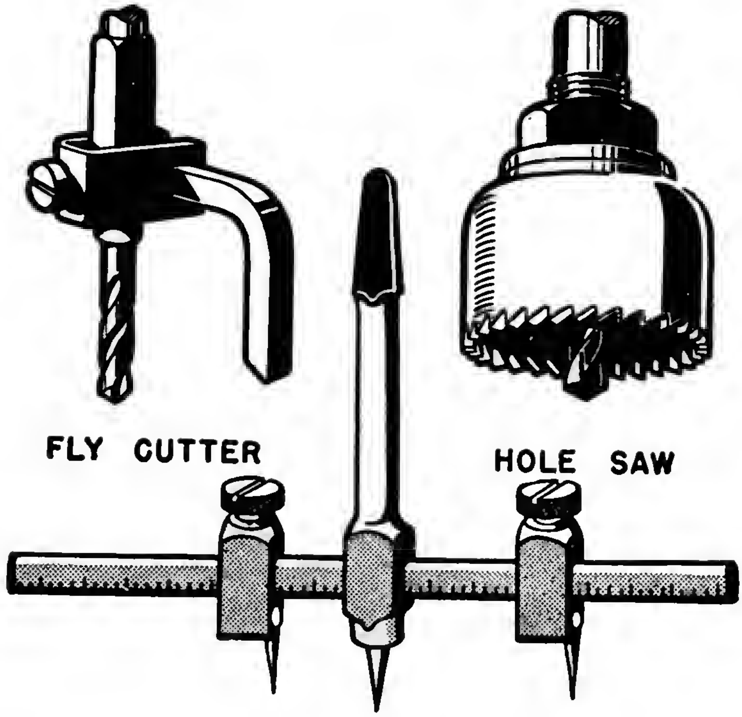


Figure 207.—Gasket cutter, fly cutter, and hole saw.

HOLE SAWS are not adjustable, but come in diameters that vary by 1/8 inch, from one size to the next. They are held and rotated in a drill press, but are easily overheated and must be used carefully.

The FORCEPS and PICK-UP TONGS pictured in figure 208 are tools you may not use very often, but when

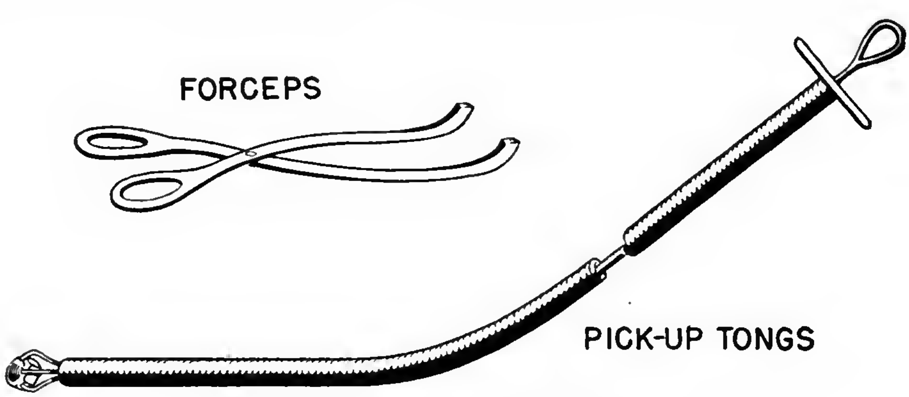


Figure 208.—Forceps and pick-up tongs.

you need them, they're worth their weight in gold. You're familiar with the plier-like forceps, but extension tongs are something special. With them you can reach into tight places—even around corners and into holes—to recover dropped nuts, bolts, screws, keys, pins and the like. If you need one of these extension tongs and don't have one, your best bet is to see a fire controlman. He keeps one handy when he is working on computers, directors, stable elements, etc.

A SHRINKAGE RULE is used by patternmakers. Metal shrinks during solidification and cooling, so the pat-

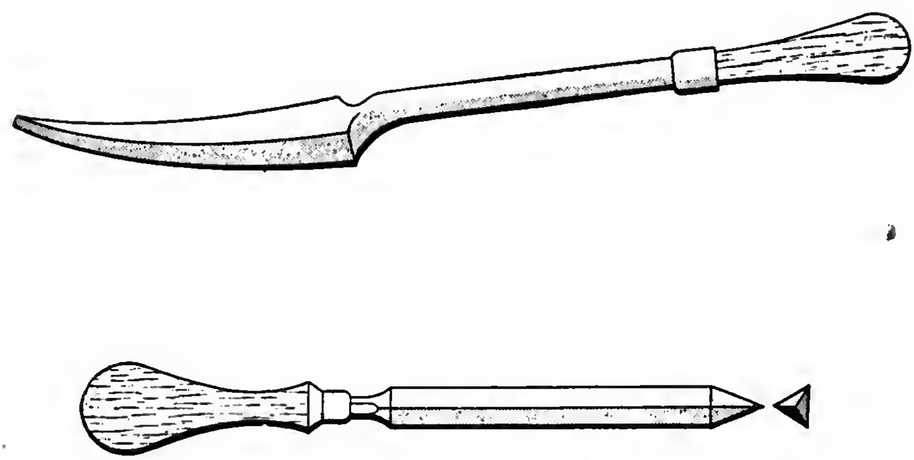


Figure 209.—Bearing scrapers.

tern for a casting is made OVERSIZE from $1/10$ inch to $5/16$ inch per foot—according to the metal used. A SHRINKAGE SCALE resembles an ordinary scale, but if you'll put them side-by-side you'll see that the shrinkage scale is "stretched out."

Because shrinkage of some metals is greater than others, separate rules for each are provided. They are called brass shrinkage rules, cast-iron shrinkage rules, etc.

BEARING SCRAPERS are used when soft-metal bearings are fitted to shafts or arbors. Two kinds are shown in figure 209. Another type has a hooked end.

A SURFACE PLATE is a flat-topped steel or cast iron plate that is heavily ribbed and reinforced on the under side. Its top surface is precision ground to form a

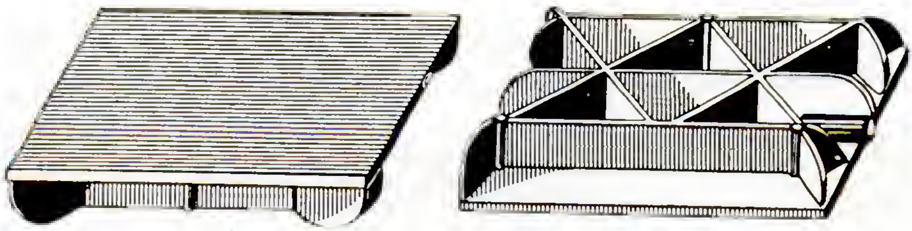


Figure 210.—Surface plate.

true, flat surface. This surface is used as a base for making layouts with precision tools, such as the surface gage, Vernier height gage, etc.

The surface plate can also be used for testing parts that must have flat surfaces. Smear a thin film of

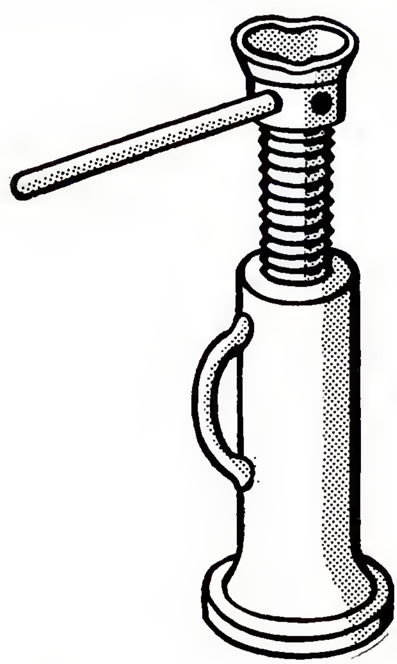


Figure 211.—Jackscrew.

Prussian Blue, or some other color pigment, on the surface of the plate. Rub the flat surface over the plate and the color pigment will stick to the high spots.

The surface plate should be covered when not in use to prevent scratching, nicking, and denting. It must be handled carefully to prevent warping (twisting). Never use the surface plate as an anvil or workbench—except for precision layout work (marking and measuring).

The JACKSCREW is a simple tool used to raise or lower heavy objects. It can also be used horizontally to push heavy objects or machinery into place.

Figure 212.—Suction type spray gun in use.

PAINT SPRAY GUNS

Plenty of Navy paint is still put on by hand with a brush, but a SPRAY GUN speeds up the job when large areas or surfaces must be painted. The SUCTION TYPE GUN, shown being used in figure 212, is for smaller jobs, as it only holds a quart of paint. The paint, or other finishing material, is sucked into the gun nozzle by compressed air which is forced past the top end of

the feed tube. The same stream of compressed air atomizes (breaks into fine particles) the paint and sprays it from the nozzle.

The RESPIRATOR, which the sailor is shown wearing in figure 212, must be worn when the spray gun is used. It prevents atomized particles of paint, solvent fumes, and gases from entering your lungs.

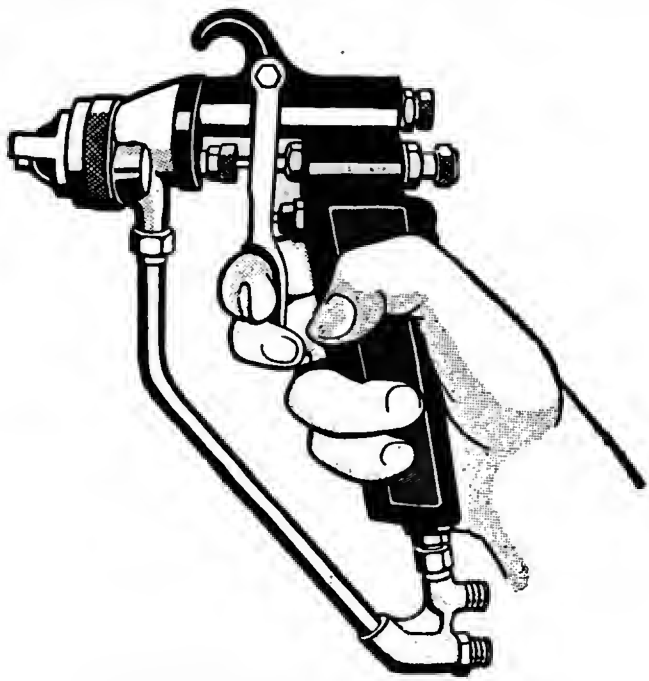


Figure 213.—Pressure-feed spray gun.

The PRESSURE-FEED GUN, figure 213, is fed from a large, sealed, pressure tank. Notice that this gun has two hose line fittings—one for paint and the other for compresed air.

Both the suction type and pressure-feed guns have small air passages and valve openings that must be thoroughly cleaned out before the finishing material dries hard in them. The best cleaning agent is the solvent that's used as a thinner for the spray material.

GREASE GUN AND PUMPS

One of the latest types of pressure grease guns used by the Navy is shown in figure 214. It resembles other

grease guns, but is filled through the end of the handle by means of a special LOADER PUMP. The pump fits a standard 11¼-inch, 25-pound grease bucket. This gun delivers one pound of grease with 770 full strokes of the handle. Three strokes should be shot into most fittings. Use the grease that's SPECIFIED for the installation.

The big advantage of this type of gun over the old

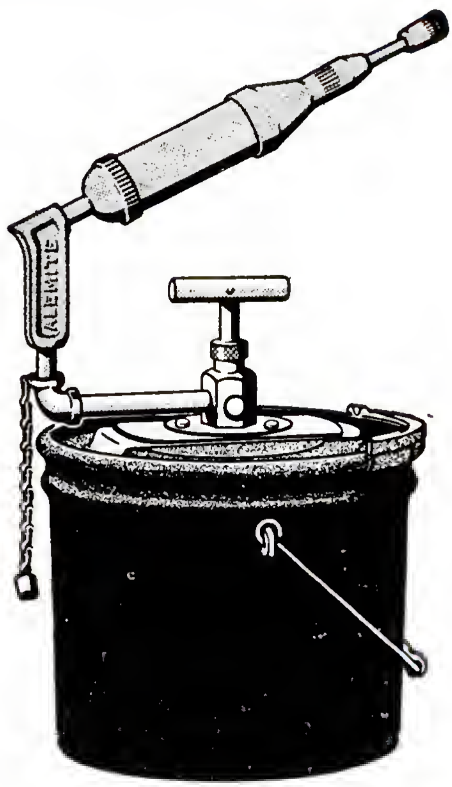


Figure 214.—Grease gun and loader.

"muzzle-loader" type is that there is little danger of dirt getting into the grease. A plug is screwed into the end of the gun handle after the gun is filled, and a cap is chained to the loader pump. This cap keeps dirt out of the pump when the gun is removed after loading.

The high pressure GREASE PUMP is used when considerable quantities of grease are required. It might

be used, for example, to grease the roller paths of a 3″/50 gun mount.

This pump is mounted on a standard 11¼-inch, 25-pound grease bucket, and the whole outfit is used as

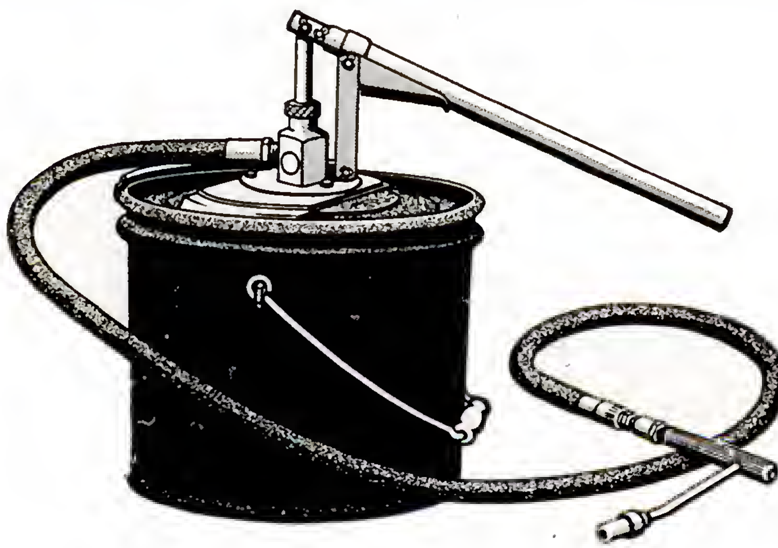


Figure 215.—Pressure grease pump.

a unit. The grease pump delivers a pound of grease with every 35 full strokes of the pumping lever. One full stroke of the grease pump puts out 22 times as much grease as one stroke of the grease gun.

CHAPTER 14

ABRASIVES

ABRASIVE ACTION

The soles of your shoes wear out because of ABRASIVE ACTION. If you walked only on such surfaces as grass, linoleum or smooth wood, your shoe soles would last indefinitely. But because you do a lot of walking on sand, gravel, cinders, rocks and concrete, your soles wear down rapidly. Such wear results from the greater abrasive action of those materials.

Abrasives are materials that wear away, or cut away, other materials by frictional contact—rubbing. These characteristics can do many shop chores for you. The primary requirement for a satisfactory abrasive is that it must be harder than the material on which it is used. Abrasives you will use vary from coarse grits that are used for fast cutting, to powders as fine as talcum that are used only for polishing.

ABRASIVE MATERIALS

NATURAL abrasives are those made from materials found in a natural state. The FLINT and GARNET grits of ordinary sandpaper are natural abrasives.

EMERY and CORUNDUM are other commonly used natural abrasives. Emery is about 60 percent aluminum oxide and 40 percent iron oxide. Corundum is about 85 percent aluminum oxide and 15 percent iron oxide. Both of these abrasives are used to manufacture cheap grades of abrasive sheets, belts, disks, and grinding wheels.

ARTIFICIAL ABRASIVES have largely replaced natural abrasives for use on metal. The two principal artificial abrasives are SILICON CARBIDE and ALUMINUM OXIDE. Silicon carbide is made by heating coke, sawdust, and pure silica sand to a high temperature in an electric furnace. Aluminum oxide is also made in an electric furnace, but it's made from bauxite ore—the same ore from which aluminum is made.

Abrasive materials are crushed into small particles—grits or grains—and these particles are used in the manufacture of sheets, belts, grinding wheels, etc.

GRAIN SIZE

The SIZE of an abrasive grain is determined by MESH MEASUREMENT, and designated by the NUMBER of the mesh through which the grain will pass. If a sieve has 46 spaces per linear inch, the grains that just pass through that mesh are size 46. Abrasive GRAINS range in size from 4 to 280. Abrasive FLOURS, powdery fine, range from 280 to 600. There are 28 standard sizes in all.

The left-hand column of figure 216 includes the commonly-used sizes of abrasives. Notice that the systems used for flint paper and emery cloth vary somewhat from the standard system used for garnet and artificial abrasives.

ABRASIVE GRAIN SIZES

Garnet Silicon Carbide Aluminum Oxide	Flint Paper	Emery Cloth	
400			
320 or 10/0			
240 or 7/0	5/0		Very Fine
220 or 6/0	4/0		
	3/0		
180 or 5/0		3/0	
150 or 4/0		2/0	
	2/0		Fine
120 or 3/0			
	0	0	
100 or 2/0			
	1/2	1/2	
80 or 0		1	
	1	1 1/2	
60 or 1/2			Medium
		2	
50 or 1	1 1/2		
40 or 1 1/2	2	2 1/2	
36 or 2			Coarse
30 or 2 1/2	3	3	
24 or 3	3 1/2		
20 or 3 1/2			Very Coarse
16 or 4			

Figure 216.—Comparative chart of abrasive grain sizes.

You'll find the grain size marked on abrasive sheets, disks, belts, grinding wheels, etc.

BONDS FOR ABRASIVES

Flint and garnet sandpaper is made by sticking the grains on a tough paper backing sheet with hide glue. The glue is the BOND in this case. The better grades of garnet paper are bonded with special resins. These sheets or belts may be used with water or oil for "wet"

sanding. The cheaper hide-glue bond disintegrates when used with liquids.

The abrasive grains of grinding wheels are held together by special bonds, the type depending on the use of the wheel. Grinding wheels are made by mixing the abrasive grains and the bonding material together, pressing the mixture into the desired shape, and baking it in an oven.

SHELLAC BOND wheels are used for sharpening tools and finish grinding. SILICATE BOND wheels are used when the heat generated in grinding must be kept at a minimum. Large diameter, slow-turning wheels are usually of this type. VITRIFIED wheels are bonded with clay or flint at high temperatures. These wheels are porous and do not clog with metal as rapidly as other wheels. Vitrified wheels of coarse grain are used where rapid removal of metal is desired. Fine-grain wheels are used for precision grinding.

VULCANITE wheels are bonded with rubber by a vulcanizing process. They are strong and tough. Thin "cut-off" wheels and wheels for high-speed grinding are rubber-bonded. RESINOID BOND wheels are bonded with synthetic resins. These wheels may be operated at high speeds and are especially good for fast, rough grinding. You'll see them used a lot in foundry, forge, and welding shops.

GRINDING WHEEL SELECTION

Many workmen INCORRECTLY refer to all grinding wheels as emery wheels. Emery grinding wheels are about as obsolete as wooden warships. Aluminum oxide and silicon carbide wheels have largely replaced emery wheels.

ALUMINUM OXIDE WHEELS are best for grinding materials of high tensile strength (materials that are hard or tough) such as—

Carbon steels	Malleable iron	Tough bronze
Alloy steels	Wrought iron	Tungsten

Two of the common trade names for aluminum oxide products are Alundum and Aloxite.

SILICON CARBIDE WHEELS are used to grind materials of low tensile strength. Use them to grind—

Cast iron	Copper
Brass	Bakelite
Common bronze	Rubber
Aluminum	Leather

Two of the common trade names for silicon carbide abrasives are Carborundum and Crystolon.

Grinding wheels are GRADED according to softness and hardness. A soft wheel is one whose grains wear

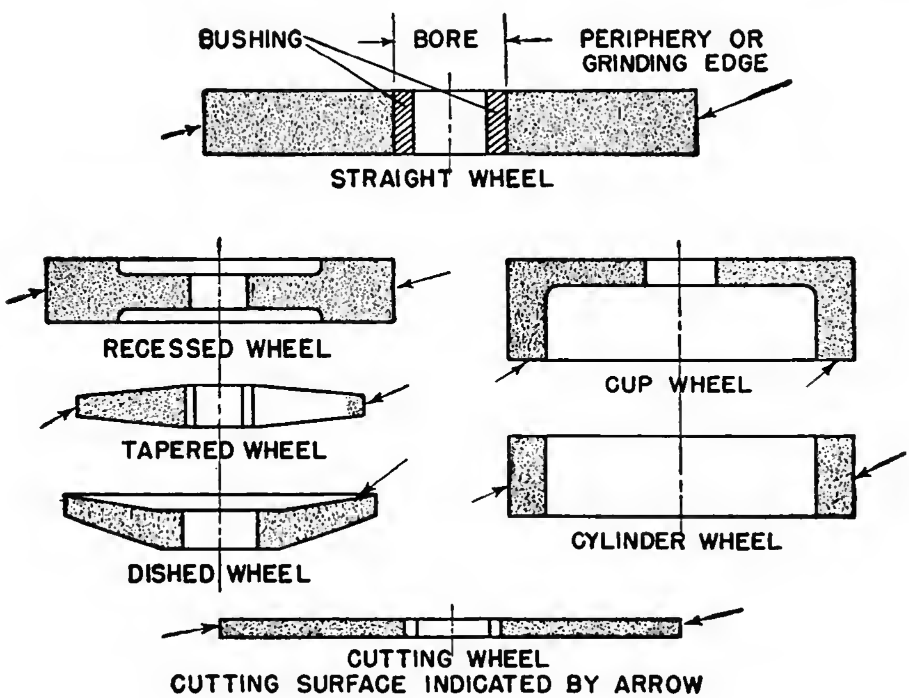


Figure 217.—Grinding wheel shapes.

away rapidly and are easily broken. Soft wheels should be operated at slow speeds. High-speed wheels are medium-hard or hard.

Grinding wheels are manufactured in a great variety of SHAPES, SIZES, and BORES. An ordinary bench grinder mounts two wheels of the same size, shape, and bore. They are from ½ to 1 inch wide, 6,

8, or 10 inches in diameter, and have an arbor hole (bore) of ½ to 1 inch. One wheel is usually coarse for rough grinding, the other fine for tool sharpening and finish grinding.

Sectional views of grinding wheels are shown in figure 217.

Wheels of special shape are used on surface grinding machines, wet-wheel grinders, small hand-held grinders, etc. A GUMMING WHEEL is used to grind the "gullets" between the teeth of circular rip saws. CUT-OFF WHEELS are used to cut metal in much the same way that circular saws cut wood. Both gumming and cut-off wheels are thin and require a strong, elastic bonding material.

Select a 14- or 16-grain wheel for coarse, rough grinding on castings and weld beads. For general shop work a 24-grain wheel is satisfactory. Use a 46-grain wheel for most small-tool grinding, and a 60 for grinding twist drills and lathe cutting tools.

Carborundum or Alundum wheels, with vitrified bond, are usually best for general grinding.

Slow-turning OILSTONE WHEELS, which are soft and porous, are best for grinding keen edges on plane irons, knives, and other wood cutting tools. These wheels are mounted on combination grinding machines, usually of the pedestal type. An abrasive wheel of this kind should be soaked with kerosene while it is being used.

USING THE BENCH GRINDER

You will use the bench grinder to sharpen tools, dress screwdrivers, etc., and to shape and smooth metal stock. Avoid grinding non-ferrous metals (brass, copper, aluminum, etc.) on the bench grinder unless you use special grinding wheels.

A common type of bench grinder is shown in figure 218. Notice the TOOL RESTS. They should be kept

close to the periphery (outside surface) of the grinding wheel. The space between a wheel and tool rest should be about 1/16 inch—never over 1/8 inch. A wheel should be mounted as shown in figure 218, to prevent stresses and strains from cracking and breaking the wheel.

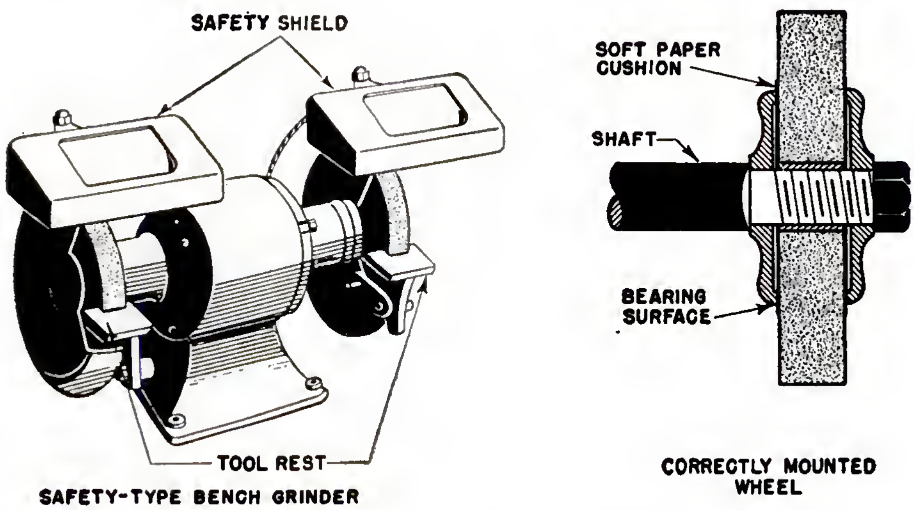


Figure 218.—Bench grinder; mounting a wheel.

Modern grinders are usually provided with good GUARDS for your safety. A cover guard encloses about 3/4 of the wheel. An adjustable eyeshield of non-shatterable glass, with a built-in lighting system, is standard equipment for the best grinders. If such a shield is not provided, protect your eyes with GOGGLES.

Be careful to avoid jamming the wheel or forcing it sideways with the tool or stock you are grinding. It takes a faster man than YOU to dodge the flying fragments of a broken grinding wheel.

DRESSING AND TRUING

A grinding wheel often gets "out-of-round" and the peripheral surface often gets out of shape. When that situation occurs, it's time for you to DRESS

or TRUE the wheel. A cheap and satisfactory DRESSING TOOL is pictured in figure 219. To use it you merely push it against the grinding wheel as the wheel revolves, and move it sideways across the periphery.

After a wheel has been used for some time it becomes clogged—that is, filled with metal, dirt, grease, etc. The abrasive grains may become rounded and dull. When these conditions are present, the dressing tool may be used to CLEAN and SHARPEN the wheel.

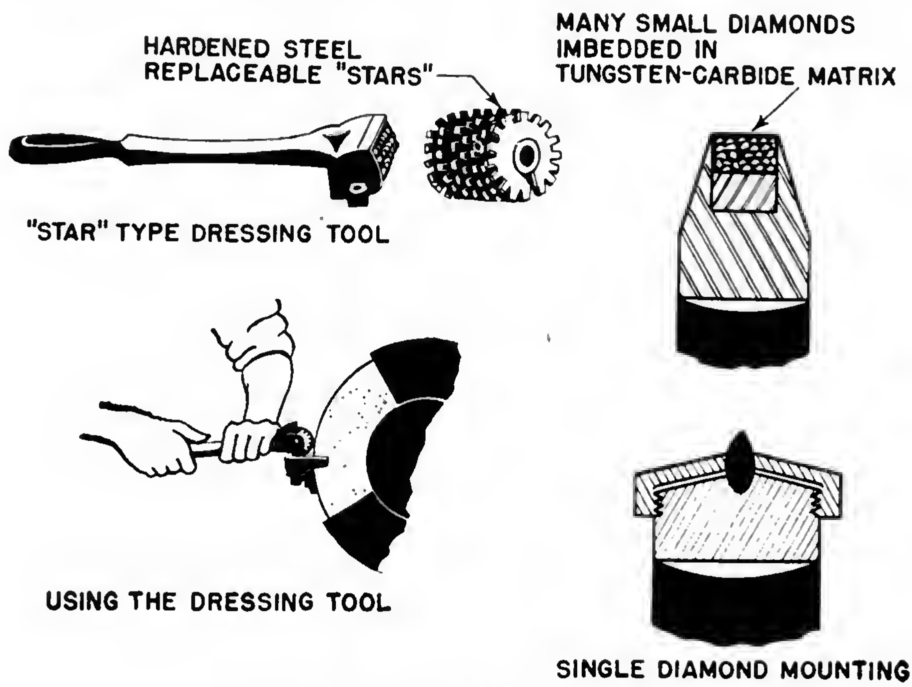


Figure 219.—Wheel dressing tools.

The dressing tool cuts away the clogged surface and breaks up the rounded grains so that new, sharp, cutting edges are exposed.

Truing can also be done with MOUNTED DIAMONDS, especially on wheels used for precision grinding. For precision truing the diamond tool is held and moved in a special fixture. The diamond tool is a great deal more expensive than the star-wheel type of dressing tool, however, and there may not be one in your shop.

OFF-HAND GRINDING

You do OFF-HAND GRINDING with a portable grinding tool. Small pneumatic grinders are held in one hand like a pencil. The grinding wheel is chucked in much the same way as a drill bit is chucked in a power

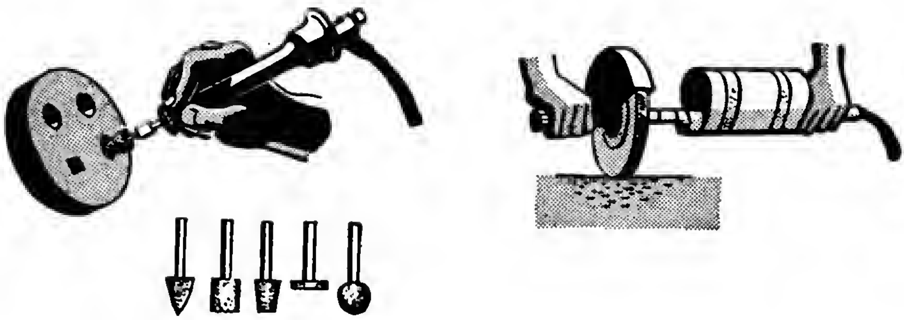


Figure 220.—Portable pneumatic grinders.

drill. The pneumatic grinder with two handles is used for rough and heavy work—smoothing castings and welds, rounding corners, etc. This tool is also used with circular wire brushes to clean metal surfaces.

ABRASIVE SHEETS, BELTS, AND DISKS

FLINT SANDPAPER is used for sanding wood. It is light in color and inexpensive but wears away rapidly. Sheets are usually 9 inches by 11 inches. GARNET SANDPAPER sheets are also 9 inches times 11 inches, and are reddish brown in color. A sheet of garnet paper lasts 3 or 4 times as long as a sheet of flint paper, but is more expensive.

Cloth sheets, belts, and disks come coated with garnet for woodworking, and with emery, aluminum oxide, or silicon carbide for sanding any solid material.

Cloth or paper-backed abrasives, used for removing paint and other clogging materials, have SPACED GRAINS (open coat). Ordinary abrasive papers and cloths have CLOSED coats.

Abrasive belts are mounted on the pulleys of special portable or bench sanding machines. Disks are mounted on metal wheels with a special adhesive material. Combination belt and disk bench sanders are often used in small shops.

OTHER ABRASIVES

OILSTONES are used for honing edged tools. Use one to remove the "wire-edge" left by the grinder. Most oilstones are about 1″ × 2½″ × 8″ in size. One face is usually coarse, and the other face fine.

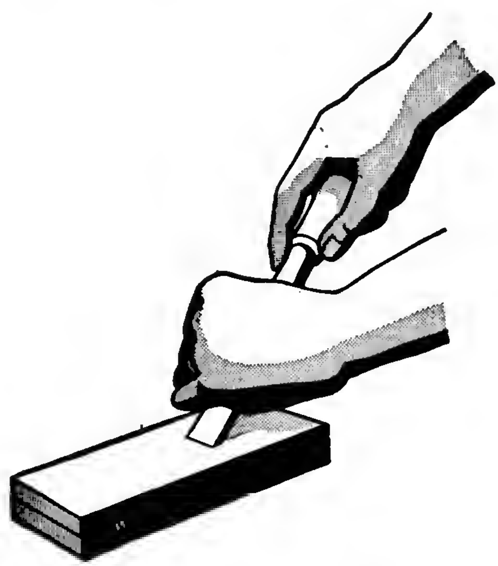


Figure 221.—Oilstone.

Oilstones are made of silicon carbide, aluminum oxide, or natural stone. The natural stones have exceptionally fine grains and are unsurpassed for putting razor edges on fine cutting tools. The finest natural stone is known as Hard Arkansas. Other good stones are Soft Arkansas and Washita.

POWDERED ABRASIVES are used for lapping, valve-grinding, polishing, and buffing. PUMICE STONE is a light gray, natural powder that's used to clean metal surfaces and to smooth painted, enameled, varnished,

and lacquered surfaces. Pumice is used with oil or water and rubbed with a cork or felt pad. Grain sizes of pumice are designated as F (fine), FF (medium fine), and FFF (very fine).

ROTTEN STONE is a fine gray powder that's used with paraffin oil to put a high polish on a finished surface. Rotten stone removes very little material—it's so fine that it feels "velvety" when you rub some of it between your fingers.

VALVE-GRINDING COMPOUND is made of fine abrasive powders (emery or artificial) mixed with oil or grease. The abrasive action is obtained by coating the valve face with compound and rubbing it against the valve seat.

LAPPING involves the same principle as valve grinding, but a still finer abrasive powder is used. Lapping is usually done with steel blocks, forms, or wheels. It is a precision operation, as only .0002 to .0005 inch of metal is removed.

CROCUS CLOTH is an extremely fine polishing abrasive. The cloth backing is coated with ferrous oxide. It's used like emery cloth but is so fine that its surface feels smooth to your fingertips.

ROUGE is the polishing material you'll use for putting a "supershine" on metal surfaces. It's made of ferric oxide and supplied in bar form. It's used on CLOTH BUFFING WHEELS to obtain those "mirror" finishes on metal surfaces. The buffing wheels may be mounted on a special BUFFER HEAD or used with a power drill. WIRE BRUSH WHEELS may be used on the buffer head to clean metal surfaces.

TIPS ON SANDING WOOD

When you use sandpaper by hand, tear the sheets into four or six pieces. To do this lay the sandpaper face down and tear along a straight edge. Use a wood,

rubber, or cork block to "back-up" the sandpaper. The block shown in figure 222 is just the right size if you tear the sheet into six pieces, as shown.

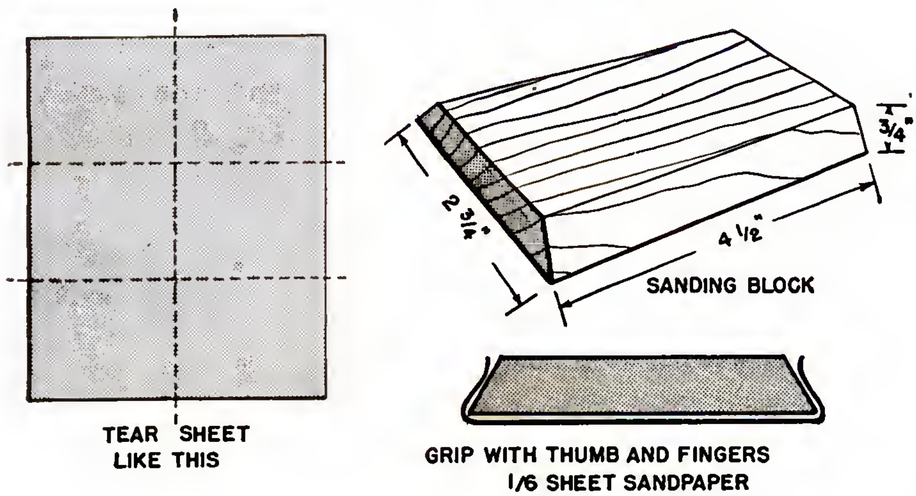


Figure 222.—Tearing sandpaper; sanding block.

Sand with the grain of the wood to avoid scratches. Use coarse No. 1 paper first, then No. ½, and finish with $^2/_0$ or $^3/_0$. Remove the dust as it accumulates.

When you're using a belt sander, or a disk sander, avoid "digging" and "gouging." Belt sanders are better for sanding wood because they can be used to sand with the grain.

APPENDIXES

APPENDIX I

FRACTIONS AND DECIMAL EQUIVALENTS

$\frac{1}{64}$	.015625
$\frac{1}{32}$	.03125
$\frac{3}{64}$	.046875
$\frac{1}{16}$	.0625
$\frac{5}{64}$	.078125
$\frac{3}{32}$	.09375
$\frac{7}{64}$	.109375
$\frac{1}{8}$	.125
$\frac{9}{64}$	.140625
$\frac{5}{32}$	.15625
$\frac{11}{64}$	.171875
$\frac{3}{16}$	.1875
$\frac{13}{64}$	.203125
$\frac{7}{32}$	.21875
$\frac{15}{64}$	.234375
$\frac{1}{4}$	.25
$\frac{17}{64}$	.265625
$\frac{9}{32}$	.28125
$\frac{19}{64}$	.296875
$\frac{5}{16}$	.3125
$\frac{21}{64}$	.328125
$\frac{11}{32}$	.34375
$\frac{23}{64}$	.359375
$\frac{3}{8}$	.375
$\frac{25}{64}$	.390625
$\frac{13}{32}$	.40625
$\frac{27}{64}$	.421875
$\frac{7}{16}$	.4375
$\frac{29}{64}$	.453125
$\frac{15}{32}$	.46875
$\frac{31}{64}$	.484375
$\frac{1}{2}$	.5
$\frac{33}{64}$	.515625
$\frac{17}{32}$	.53125
$\frac{35}{64}$	.546875
$\frac{9}{16}$	.5625
$\frac{37}{64}$	.578125
$\frac{19}{32}$	.59375
$\frac{39}{64}$	.609375
$\frac{5}{8}$	.625
$\frac{41}{64}$	.640625
$\frac{21}{32}$	.65625
$\frac{43}{64}$	.671875
$\frac{11}{16}$	.6875
$\frac{45}{64}$	.703125
$\frac{23}{32}$	.71875
$\frac{47}{64}$	.734375
$\frac{3}{4}$	.75
$\frac{49}{64}$	.765625
$\frac{25}{32}$	.78125
$\frac{51}{64}$	.796875
$\frac{13}{16}$	.8125
$\frac{53}{64}$	.828125
$\frac{27}{32}$	.84375
$\frac{55}{64}$	.859375
$\frac{7}{8}$	.875
$\frac{57}{64}$	.890625
$\frac{29}{32}$	.90625
$\frac{59}{64}$	.921875
$\frac{15}{16}$	.9375
$\frac{61}{64}$	.953125
$\frac{31}{32}$	.96875
$\frac{63}{64}$	.984375
1	1.

APPENDIX II
STANDARD WIRE GAGES

	Spring steel, flat wire, strip steel, steel tube, aluminum tube, brass tube	Nickel silver, copper, aluminum,* brass	Steel sheet, steel plate, nickel sheet, Monel metal	Steel wire, iron wire	Music wire
Gage No.	Birmingham or stubs	American or B. & S.†	U.S. Standard	Washburn & Moen	Music wire Standard
6/0	....	0.5800	0.4687	0.4615	0.004
5/0	....	.5165	.4375	.4305	.005
4/0	0.454	.4600	.4062	.3938	.006
3/0	.425	.4096	.3750	.3625	.007
2/0	.380	.3648	.3437	.3310	.008
1/0	.340	.3249	.3125	.3065	.009
1	.300	.2893	.2812	.2830	.010
2	.284	.2576	.2656	.2625	.011
3	.259	.2294	.2500	.2437	.012
4	.238	.2043	.2343	.2253	.013
5	.220	.1819	.2187	.2070	.014
6	.203	.1620	.2031	.1920	.016
7	.180	.1443	.1876	.1770	.018
8	.165	.1285	.1718	.1620	.020
9	.148	.1144	.1562	.1483	.022
10	.134	.1019	.1406	.1350	.024
11	.120	.0907	.1250	.1205	.026
12	.109	.0808	.1093	.1055	.029
13	.095	.0719	.0937	.0915	.031
14	.083	.0640	.0781	.0800	.033
15	.072	.0570	.0703	.0720	.035
16	.065	.0508	.0625	.0625	.037
17	.058	.0452	.0562	.0540	.039
18	.049	.0403	.0500	.0475	.041
19	.042	.0359	.0437	.0410	.043
20	.035	.0319	.0375	.0348	.045
21	.032	.0284	.0343	.0317	.047
22	.028	.0253	.0312	.0286	.049
23	.025	.0225	.0281	.0258	.051
24	.022	.0201	.0250	.0230	.055
25	.020	.0179	.0218	.0204	.059
26	.018	.0159	.0187	.0181	.063
27	.016	.0142	.0171	.0173	.067
28	.014	.0126	.0156	.0162	.071
29	.013	.0112	.0140	.0150	.075
30	.012	.0100	.0125	.0140	.080
31	.010	.0089	.0109	.0132	.085
32	.009	.0079	.0101	.0128	.090
33	.008	.0071	.0093	.0118	.095
34	.007	.0063	.0085	.0104	.100
35	.005	.0056	.0078	.0095	.106
36	.004	.0050	.0070	.0090	.112
37	....	.0044	.0066	.0085	.118
38	....	.0039	.0062	.0080	.124

*Except Aluminum Tubing. †B. & S. is Brown & Sharpe.

APPENDIX III

TWIST DRILL SIZES

Size	Decimal equivalents	Size	Decimal equivalents	Size	Decimal equivalents
½	0.5000	C	0.2420	30	0.1285
$\frac{31}{64}$	.4844	B	.2380	⅛	.1250
$\frac{15}{32}$	.4687	$\frac{15}{64}$	.2344	31	.1200
$\frac{29}{64}$	.4531	A	.2340	32	.1160
$\frac{7}{16}$	.4375	No. 1	.2280	33	.1130
$\frac{27}{64}$	.4219	2	.2210	34	.1110
Z	.4130	$\frac{7}{32}$	.2187	35	.1100
$\frac{13}{32}$	.4062	3	.2130	$\frac{7}{64}$	.1094
Y	.4040	4	.2090	36	.1065
X	.3970	5	.2055	37	.1040
$\frac{25}{64}$	.3906	6	.2040	38	.1015
W	.3860	$\frac{13}{64}$	.2031	39	.0995
V	.3770	7	.2010	40	.0980
⅜	.3750	8	.1990	41	.0960
U	.3680	9	.1960	$\frac{3}{32}$	.0937
$\frac{23}{64}$	.3594	10	.1935	42	.0935
T	.3580	11	.1910	43	.0890
S	.3480	12	.1890	44	.0860
$\frac{11}{32}$	.3437	$\frac{3}{16}$	.1875	45	.0820
R	.3390	13	.1850	46	.0810
Q	.3320	14	.1820	47	.0785
$\frac{21}{64}$	.3281	15	.1800	$\frac{5}{64}$	.0781
P	.3230	16	.1770	48	.0760
O	.3160	17	.1730	49	.0730
$\frac{5}{16}$	.3125	$\frac{11}{64}$	.1719	50	.0700
N	.3020	18	.1695	51	.0670
$\frac{19}{64}$	.2969	19	.1660	52	.0635
M	.2950	20	.1610	$\frac{1}{16}$	.0625
L	.2900	21	.1590	53	.0595
$\frac{9}{32}$	.2812	22	.1570	54	.0550
K	.2810	$\frac{5}{32}$	.1562	55	.0520
J	.2770	23	.1540	$\frac{3}{64}$	.0469
I	.2720	24	.1520	56	.0465
H	.2660	25	.1495	57	.0430
$\frac{17}{64}$	.2656	26	.1470	58	.0420
G	.2610	27	.1440	59	.0410
F	.2570	$\frac{9}{64}$	.1406	60	.0400
E ¼	.2500	28	.1405		
D	.2460	29	.1360		

APPENDIX IV
AMERICAN NATIONAL FORM THREADS

(Thread and Tap Drill Sizes)

Nominal size	Thr'd series	Major diameter, inches	Root diameter, inches	Tap drill to produce approx. 75% full thread	Decimal equivalent of tap drill
0–80	N. F.	.0600	.0438	$\frac{3}{64}$	.0469
64	N. C.	.0730	.0527	53	.0595
72	N. F.	.0730	.0550	53	.0595
2–56	N. C.	.0860	.0628	50	.0700
64	N. F.	.0860	.0657	50	.0700
3–48	N. C.	.0990	.0719	47	.0785
56	N. F.	.0990	.0758	45	.0820
4–40	N. C.	.1120	.0795	43	.0890
48	N. F.	.1120	.0849	42	.0935
5–40	N. C.	.1250	.0925	38	.1015
44	N. F.	.1250	.0955	37	.1040
6–32	N. C.	.1380	.0974	36	.1065
40	N. F.	.1380	.1055	33	.1130
8–32	N. C.	.1640	.1234	29	.1360
36	N. F.	.1640	.1279	29	.1360
10–24	N. C.	.1900	.1359	25	.1495
32	N. F.	.1900	.1494	21	.1590
12–24	N. C.	.2160	.1619	16	.1770
28	N. F.	.2160	.1696	14	.1820
$\frac{1}{4}$–20	N. C.	.2500	.1850	7	.2010
28	N. F.	.2500	.2036	3	.2130
$\frac{5}{16}$–18	N. C.	.3125	.2403	F	.2570
24	N. F.	.3125	.2584	I	.2720
$\frac{3}{8}$–16	N. C.	.3750	.2938	$\frac{5}{16}$	.3125
24	N. F.	.3750	.3209	Q	.3320
$\frac{7}{16}$–14	N. C.	.4375	.3447	U	.3680
20	N. F.	.4375	.3726	$\frac{25}{64}$	.3906
$\frac{1}{2}$–13	N. C.	.5000	.4001	$\frac{27}{64}$	.4219
20	N. F.	.5000	.4351	$\frac{29}{64}$	.4531
$\frac{9}{16}$–12	N. C.	.5625	.4542	$\frac{31}{64}$	.4844
18	N. F.	.5625	.4903	$\frac{33}{64}$	.5156
$\frac{5}{8}$–11	N. C.	.6250	.5069	$\frac{17}{32}$	.5312
18	N. F.	.6250	.5528	$\frac{37}{64}$	.5781
$\frac{3}{4}$–10	N. C.	.7500	.6201	$\frac{21}{32}$	.6562
16	N. F.	.7500	.6688	$\frac{11}{16}$	.6875
$\frac{7}{8}$– 9	N. C.	.8750	.7307	$\frac{49}{64}$	.7656
14	N. F.	.8750	.7822	$\frac{13}{16}$	.8125
1– 8	N. C.	1.0000	.8376	$\frac{7}{8}$	.8750
14	N. F.	1.0000	.9072	$\frac{15}{16}$	.9375

APPENDIX V

35mm FILM STRIPS

SA–484............Blacksmith and welder.
SN–2658.........Brazing and silver soldering.
SN–247...........Drills and drilling.
SN–6..............Drills, sharpening.
SC–632...........Files and how to use them.
SN–54.............Glue, casein—mixing and using.
SN–1453.........Hacksaws.
SN–30.............Hand shears, care and use of
SN–1575.........Layout tools and measuring instruments.
SN–292...........Making a round metal container.
SN–3..............Making a stud.
SN–184...........Metal finishing.
SN–2666.........Metals, properties of
SC–775...........Micrometer, how to use a
SN–137...........Oxyacetylene cutting.
SN–2667.........Oxyacetylene torch, setting up and lighting the
SN–2665.........Reaming, tapping and threading.
SN–825...........Rule, the use of—Measuring tools.
SN–642...........Soldering electrical connections.
SN–48.............Soldering practice.
SN–926...........Tool kit, metalsmith's
SN–56.............Tubing, fabrication of
SN–94 ....Welders, qualification test for
SN–2655.........Welding equipment.

APPENDIX VI

16mm MOVING PICTURES

MC–541a.........Arc welding, inside of—Fundamentals.

MA–1929c.......Chisels—Use of service hand tools.

ME–267a.........Drilling a hole in a pin—Operation of the sensitive drill.

MN–142..........Drilling in metal, wood and plastics.

MA–2087b.......Drills, portable electric—Hand measuring and power tools.

MN–2337a......Pipefitting; removing a section of piping aboard ship—Shipbuilding skills.

MA–1929b.......Pliers and screwdrivers—Use of service hand tools.

MA–1929e.......Punches, drifts and bars—Use of service hand tools.

ME–1051d.......Reaming with straight hand reamers—machine shop work—Bench work.

ME–1051e.......Reaming with taper hand reamers—Machine shop work—Bench work.

MN–71............Sawing, hand.

ME–1051h.......Filing, fundamentals of—Machine shop work—Bench work.

ME–239c.........Gages, fixed—Precision measuring.

ME–239e.........Gages, height and standard indicators—Precision measuring.

MA–2087a.......Grinder, bench, operation and care of—Hand measuring and power tools.

MA–1929d......Hammers—Use of service tools.

MN–2337d......Pipefitting; fitting and installing a section of piping aboard ship—Shipbuilding skills.

MA–2594.........Soldering.

ME–1051a.......Taps and dies, cutting threads with—Machine shop work—Bench work.

MC–361...........Twist drills, uses and abuses of

ME–239d.........Vernier scale—Precision measuring.

MA–1929a.......Wrenches—Use of service hand tools.

How Well Do You Know—

USE OF TOOLS

6. What tool does a socket speed handle resemble?
7. Why should a wrench be pulled rather than pushed?
8. What is the handiest all-round wrench for light work?

CHAPTER 4
METAL-CUTTING TOOLS

1. When you cut medium- or heavy-gage metal with snips, why should you cut outside the layout line?
2. Why should you stop a cut before the ends of a hand snip's blades have been reached?
3. How can you obtain maximum leverage with hand snips in cutting heavy sheet metal?
4. What kind of "set" is usually found on hacksaw blades which have 32 teeth per inch?
5. When you're using a hacksaw, how much downward pressure should you apply (a) on the forward stroke? (b) on the back stroke?
6. What one factor causes the most hacksawing trouble?
7. Where should you look when you're pounding a cold chisel?
8. Which type of file is best for finish filing and draw filing?
9. Why should a file NEVER be used for prying?
10. What's the principle difference between single-cut and double-cut files?

CHAPTER 5
CUTTING HOLES IN METAL

1. What kind of drill bit is best for a tough drilling job?
2. List four systems by which drill sizes are classified.
3. What's a sure method of determining the diameter of any drill bit?
4. How is the spindle speed of a small bench-type drill press controlled?
5. What is a pilot hole?
6. What three precautions should a drill-press operator take to prevent injury to himself and others?
7. What is the correct lip-clearance angle for a twist drill?
8. What is a good final test for a drill that you have resharpened?

9. For what purposes are reamers used?
10. If a drill is sharp but won't cut, what's likely to be the trouble?

CHAPTER 6

THREADS AND THREAD CUTTING

1. What is basic difference between N.C. and N.F. threads of the same major diameter?
2. Why are multiple threads (double, triple, etc.) used on some threaded parts?
3. What kind of threads are usually cut on vise clamping screws?
4. What thread fit is usually specified for machine parts?
5. You may see this note on a blueprint: ¾—16NF—3.
   (a) What does the "¾" indicate?
   (b) What does the "16" tell you?
   (c) What is the meaning of "NF"?
   (d) What does the last number (3) indicate?
6. Where can you find a table that lists the tap drills for NF and NC threads?
7. What is the difference in full threads cut with taper, plug, and bottoming taps?
8. Why must a tap be "backed up"?
9. Why not drill out a broken tap?
10. When you cut matching threads the internal threads are cut first. Why?
11. What is the standard taper of pipe threads?

CHAPTER 7

METAL FASTENERS

1. What does the term "8-32" mean when applied to machine screws?
2. Some cap screw heads have drilled holes. Why?
3. What tools are used to tighten and loosen Allen set screws?
4. What two types of sheet metal screws are most commonly used?
5. What is the "grip" of a riveted joint?

CHAPTER 8

PIPE AND TUBING TOOLS

1. How are large pipe sections fastened together?
2. How many threads are ordinarily cut on the end of a pipe?
3. What is annealing?
4. What materials are used to seal the threaded joints of water and steam pipes?
5. Which size of pipe wrench works best on a ⅜-inch pipe?
6. What are three common defects of tubing flares?
7. Tubing lines should not be installed in a straight line. Why?
8. What is the melting temperature of the special bending alloys?
9. Why is it so important that piping systems be kept clear of foreign matter?
10. How can you connect tubing without the use of flares?
11. Why are the outside threads of hydraulic line fittings sometimes tinned?
12. What are three requirements of a good pipe or tubing joint?

CHAPTER 9

SOLDERING AND WELDING

1. What metals are used—and in what proportions—in the manufacture of half-and-half soft solder?
2. What is the primary purpose of a flux?
3. Why is the working end of a soldering tool made of copper?
4. How is the size of a soldering copper designated?
5. When a blow torch is used to heat a soldering copper, what color must the flame be for efficient heating?
6. What flux is used for soldering galvanized iron?
7. When you make your own dipping solution with sal-ammoniac powder and water, what proportion of each should you use?
8. What flux is usually used for soldering electrical connections?
9. What flux is usually used with silver solder?

10. What is the meaning of the word "fusion" as applied to welding.?
11. How does brazing differ from fusion welding?
12. Why do men who operate arc-welding equipment wear face masks and leather clothes?

CHAPTER 10

WOODWORKING WITH HAND TOOLS

1. Woodworking layouts are ordinarily marked with a pencil. How are they marked when a high degree of accuracy is necessary?
2. What is the meaning of the number "9" stamped on the heel of a handsaw blade?
3. When should a plane iron be honed?
4. How should you place a plane on a bench top?
5. State the foremost safety rule for using a chisel.
6. Which parts of an auger bit may be filed?
7. What number is stamped on the shank of a ⅝-inch auger bit?
8. What tool is used to cut the chamfered recess for the head of a flat head wood screw?
9. What is an "RHB" wood screw?
10. Woodworking vise jaws should have wooden faces. Why?
11. What are the "footprints" of a sloopy woodworker?

CHAPTER 11

MEASURING TOOLS

1. What kind of rule is handy for measuring on curved surfaces?
2. What type of caliper is best for measuring the diameter of a narrow piston ring groove?
3. Name the three heads that may be used with the blade of a combination square set.
4. What two parts of an inside micrometer come in contact with the stock being measured?
5. On a mike sleeve scale what do the numbers above the horizontal line indicate?
6. What is the purpose of a vernier scale on a micrometer?
7. Name two micrometers that have reverse scales.

CHAPTER 12

GAGES AND INDICATORS

1. For what purpose are most gages used?
2. What tool is used to measure spark plug gaps?
3. What is a United States Standard gage?
4. What words will you find stamped on the most commonly used type of plug gages?
5. What type of plug gage does a Gunner's Mate use?
6. How accurate are gage blocks?

CHAPTER 13

SPECIAL TOOLS

1. What special rule is used by sheet metal workers?
2. What is a stake plate?
3. What is the name of the pointed end of an anvil?
4. What forging tools are used to shape round and oval objects?
5. Who is the "sandman" of the Navy?
6. The cope is the top part of a flask. What is the name of the bottom part?
7. How is sand packed in a flask if no power equipment is available?
8. How is the gas pressure in a sand mold relieved?
9. What tool is a combination end wrench and alining tool?
10. Name two types of paint spray guns.
11. Why does the Navy prefer the handle-loading grease gun to the old type?

CHAPTER 14

ABRASIVES

1. Why do your shoe soles wear out?
2. List four natural abrasives.
3. What abrasive material is made artificially from bauxite ore?

4. What material is used as the bond for common sandpaper?
5. Which of the artificial abrasives is best for grinding cast iron?
6. Why do gumming and cut-off wheels require a tough, elastic bond?
7. What type of abrasive wheels are best for putting a keen edge on wood-cutting tools?
8. When does a grinding wheel need to be "dressed"?
9. What is the size of sandpaper sheets?
10. What is the color of garnet abrasives?
11. What is the best type of natural oilstone?
12. Name the cloth-backed abrasive used for polishing metal.
13. A belt sander is superior to a disk sander for smoothing the flat surfaces of boards. Why?

ANSWERS TO QUIZ

CHAPTER 1

KEEPING OUR NAVY SHIPSHAPE

1. You can learn about tools by asking questions of your shipmates; by studying your Training Course; and by working with tools in the shop.
2. In a combat zone the supply of tools is limited. If you break or lose tools, it may be a long time before you can get replacements for them.
3. Check them for dirt and rust; clean and oil them if they need it.
4. Plan your work step by step. Decide what tools you'll need and how to use them most efficiently. Then—be sure you're RIGHT.

CHAPTER 2

GENERAL-PURPOSE TOOLS

1. According to the weight of the hammer head.
2. "Shake hands" with the handle. Don't choke the hammer by gripping the handle at the throat.
3. Replace the handle. Spread the small end tight in the eye of the head by driving in a steel wedge.
4. Only when it is broken or becomes rounded from wear.
5. Standard, offset, and Phillips-type screwdrivers.
6. Heavy-duty screwdrivers which have special square bits.
7. Never let any part of your body get in front of the sharp tip when the tool is being used.
8. A drift.
9. Center punch.
10. Metal inserts mounted on vise jaws to protect work held in the vise.

CHAPTER 3

WRENCHES

1. Chrome-vanadium steel wrenches are extra strong, and light in weight.
2. Spanner wrenches.

3. Twelve.
4. By the "feel"—which comes only from practice.
5. An open-end and a box-end.
6. A carpenter's brace.
7. To save you from cracking your knuckles if the wrench slips.
8. The adjustable open-end wrench.

CHAPTER 4
METAL-CUTTING TOOLS

1. Because the cut edges of the metal will be rough. By cutting outside the line you leave some surplus metal for burring and smoothing.
2. Because the points of the snips will tear the metal if they come together.
3. Use the throat of the snips, and rest the lower handle on the bench top.
4. Undulated (wave) set.
5. Just enough pressure so each tooth will cut on the forward stroke. No pressure on the back stroke.
6. Too much speed. Hold speed down to 40 or 50 strokes per minute.
7. Keep your eyes on the POINT of the chisel. Don't look at the hammer, or the head of the chisel.
8. The single-cut mill file.
9. Because the file is brittle. It may snap in two.
10. Single-cut file teeth are all parallel. Double-cut files have teeth cut in two directions (criss-cross).

CHAPTER 5
CUTTING HOLES IN METAL

1. A high-speed drill.
2. Fractional; number; letter; and metric.
3. Measuring the diameter with a micrometer.
4. By the use of cone-step V-pulleys and V-belts.
5. A small hole used to start and guide a large drill.
6. Clamp the stock securely; use the correct speed; and romove the chuck key.

7. 12 to 15 degrees.
8. Try it out by drilling a sample hole in a piece of scrap. The lips should cut evenly, and the hole should be accurate in diameter.
9. To smooth and enlarge holes to exact size.
10. It probably has no lip clearance.

CHAPTER 6

THREADS AND THREAD CUTTING

1. The pitch differs. N. C. threads have fewer thread points per inch than N. F. threads.
2. Multiple threads provide fast travel of the threaded parts.
3. Square threads.
4. Medium fit (number 3).
5. (a) Major diameter of the thread.
   (b) Number of threads per inch.
   (c) National Fine thread series.
   (d) Thread fit number 3—(medium).
6. In appendix IV of this book. You also may have shop charts or pocket cards, that list tap drill sizes.
7. There is no difference in the threads themselves.
8. To break the chips loose.
9. The tap is as hard (or harder) than the drill.
10. Internal threads are cut with a non-adjustable tool—the tap. You cut them first, and then adjust the die to cut the external threads to fit.
11. Three-fourths inch per foot.

CHAPTER 7

METAL FASTENERS

1. The screw is number 8 (gage) and has 32 threads per inch.
2. A wire is run through these holes to "safety" the cap screw —that is, prevent it from unscrewing.
3. Special L-shaped wrenches, hexagonal in section.
4. Type A and type Z.
5. The total thickness of the riveted parts.

CHAPTER 8

PIPE AND TUBING TOOLS

1. They are welded, or held with bolted flanges.
2. As many threads as are on the die. Stop cutting when the end of the pipe is flush with the back of the die.
3. A method of softening metals by the controlled use of heat.
4. Red lead for water pipes; graphite paint for steam pipes.
5. 10-inch.
6. See figure 117
7. A straight-line tube is easily pulled loose or otherwise damaged by accidental blows. It may be pulled loose by contraction (caused by temperature changes) or by vibration.
8. About 150 degrees Fahrenheit.
9. Pumps, gages, valves, etc., are connected in pipe and tubing lines, and may be damaged by any foreign matter in a line.
10. By hard soldering or by the use of soldered fittings.
11. Tinning the threads insures a superior seal, making the joints pressure-tight.
12. The joint must be clean, tight, and strong.

CHAPTER 9

SOLDERING AND WELDING

1. 50 percent tin and 50 percent lead.
2. To prevent oxidation.
3. Because copper is an excellent heat conductor.
4. By the weight of a PAIR of coppers.
5. Light blue, almost colorless.
6. Zinc chloride ("killed" or "cut" acid).
7. Forty parts of water to one part of sal-ammoniac powder.
8. Rosin.
9. Powdered borax.
10. Melted together.
11. Brazing does not require the joined parts to be melted.
12. To protect themselves from being burned by ultra-violet rays, or by drops of metal melted by the electric arc.

CHAPTER 10

WOODWORKING WITH HAND TOOLS

1. With a sharp knife point.
2. The blade has 9 saw tooth points per inch (the pitch of the saw).
3. Immediately after it's ground; or when it is dull but has no deep nicks.
4. On its side.
5. Never allow any part of your body to get in front of the cutting edge.
6. The lips and nibs.
7. 10.
8. Countersink.
9. Round head, blued (steel).
10. To protect the stock from being scratched and dented.
11. Hammer marks or dents.

CHAPTER 11

MEASURING TOOLS

1. Flexible steel rule.
2. Firm-joint caliper (outside).
3. Square stock; protractor head; and center head.
4. Spindle and anvil.
5. Tenths of an inch.
6. To provide mike readings in ten-thousandths of an inch.
7. Depth "mikes"; inside "mikes" for small diameters (see fig. 178).

CHAPTER 12

GAGES AND INDICATORS

1. As substitutes for rules, calipers, and micrometers in checking measurements.
2. Feeler gage.
3. A circular wire and sheet gage.
4. GO and NO-GO (or NOT-GO).
5. Gun bore gage.
6. Gage blocks are accurate within a few millionths of an inch.

CHAPTER 13

SPECIAL TOOLS

1. Circumference rule.
2. A heavy steel plate with tapered square holes. It is mounted on a bench top to serve as a holder for sheet metal stakes.
3. Horn.
4. Swages.
5. The Molder.
6. Drag.
7. With a hand rammer.
8. The mold is vented with a wire, or vent rod.
9. Spud wrench.
10. Suction-type and pressure-feed type.
11. The new type eliminates the possibility of dirt getting mixed with the grease.

CHAPTER 14

ABRASIVES

1. Because of the abrasive action of some of the materials on which you walk.
2. Flint, garnet, emery, corundum.
3. Aluminum oxide.
4. Hide glue.
5. Silicon carbide.
6. They are very thin wheels.
7. Oilstone wheels.
8. When it becomes dull, clogged, out of round, or loses peripheral shape.
9. 9 by 11 inches.
10. Light reddish-brown.
11. Hard Arkansas.
12. Crocus cloth (ferrous oxide).
13. The belt sander may be used to sand WITH the grain, while the disk sander cuts with a rotary action.

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